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Progress, Status of 'Torch Plan' Analyzed

[Article by Gan Shijun [3927 1597 0193] of the Center for Promotion of Chinese Science and Technology Research and Development, Ge Yaoliang [5514 5069 5328] of the FORUM ON SCIENCE AND TECHNOLOGY IN CHINA editorial staff, and Tang Juan [0781 3197] of the State Science and Technology Commission: "Analysis of Progress, Status of the 'Torch Plan'"]

[Text] In order to promote the commercialization of new high-tech achievements, push for the establishment and development of high-tech industry, and create new avenues for deepening the reform of the S&T system, the State Science and Technology Commission began to implement the "Torch Plan" in the second half of 1988. In the past year or so, a great deal of progress has been made, which creates a new way to develop high-tech industry in China.

I. Principles and Policies

The Torch Plan is an integral part of the high-tech-industry development plan. Its objectives are:

1. To create a social environment which facilitates rapid development of high-tech industries.

2. To guide research institutes and higher-learning institutions to start hundreds of S&T businesses and to establish lateral connections with industries in order to utilize existing conditions and resources to form high-tech industry groups.

3. To develop hundreds of new high-tech products and introduce them to the world market or use them to replace imports based on results from national high-tech development programs, national and local technical projects, industrial research and development efforts, and key basic research programs, innovations from absorption and digestion of imported technology, inventions and patents.

4. To train tens of thousands of outstanding technical management people who understand technology, know how to manage and are familiar with international commerce.

Based on these objectives, the strategy of the Torch Plan is to let us be guided by the market and driven by products to prioritize key development areas, and to adopt various financing methods to support businesses, train people and create an environment to develop industries. Its principles and policies include:

1. Use the domestic market as the guide and let new high-tech products lead us to create economies of scale based on combining technology, industry and trade.

2. Based on market demand and China's existing foundation and resources, the key areas to focus on ought to be electronic information, new materials, bioengineering, new energy sources and high-efficiency energy-saving devices, and electromechanical-integration products [i.e., "mechatronics"]. In the next couple of years, we must carefully pick out products that require less investment, can be developed in a short period of time, and are highly profitable, in order to accumulate capital to develop higher-level products.

3. Use various conduits and methods to raise money.

4. Establish S&T businesses of various kinds.

5. Encourage new high-tech companies to hire technical talent from abroad, including foreign experts.

6. Construct experimental high-tech development zones, and implement various preferential treatments to create a favorable environment.

The Torch Plan is a two-tier directive program managed by both the national and local governments.

II. Progress and Results

Torch Plan measures over the past year have resulted in good progress.

1. National Torch Plan Projects Implemented

The outline of the Torch Plan pointed out that approximately 2,000 new high-tech products will be developed in the 1988-1990 period. Over 70 percent of these products will be in production and over 30 percent will be exported to earn hard currency. In the past year, various provinces and departments have submitted approximately 1,500 Torch Plan projects. After being reviewed by experts, 272 projects were identified as the first group of national Torch Plan projects. These projects are restricted to five key areas: new materials, biotechnology, electronic information, electromechanical integration, and new energy sources and high-efficiency energy conservation. These projects are characterized by advanced technical standards, mature technical results, capability for batch production or small-scale production, and good market prospects. They can be expected to earn foreign currency or can replace current imports. These products require relatively little investment, have a short development cycle, and are highly profitable. The investment-to-output-value ratio is approximately 1:5, and the replacement of profits by taxes is greater than 25 percent. In order to implement these projects, the government has provided some favorable loans. The first "Torch Cup" high-tech product exhibit was held in Beijing in May 1989. Over 800 new high-tech products that have been developed and manufactured in the past 2 years were on display. They were well received and praised.

2. Preliminary Torch Plan Bases Constructed

Since the State Council approved the construction of the Beijing New-Technology Industry Experimental Development Zone, over 20 experimental high-tech product development zones in four different models have been approved by provincial and city governments to suit their local conditions and needs. These areas have become important bases for the implementation of the Torch Plan.

The first model is to specify the area and provide centralized management and centralized operation, such as for the development zones in Beijing, Wuhan and Shenyang. The special feature is to take full advantage of existing bases to integrate technology, industry and trade in order to independently develop and grow to size.

The second model is not to have a specific area, start with whatever is available, and have centralized management and separate operation, such as with the development areas in Changsha and Harbin. The special feature is that the emphasis is on products alone, rather than on area: Start with that which is available, accumulate capital and create a market by experience. Step by step, concentrate on certain items to become the characteristics of the region.

The third model is to create a new area with long-range planning and short-term arrangements, have someone in charge of overall construction, provide centralized management, have a development type of operation, and grow in a rolling fashion, such as with the Nanjing development zone. The special feature is that the projects and the zones are being developed simultaneously in a piece-by-piece manner to create the whole area in steps.

The fourth model is to be located within a pre-existing economic and technology development zone and have it built simultaneously, such as with the development zones in Shanghai and Qingdao. The special feature is that the existing preferential treatments and basic social facilities in the economic and technology development area can be utilized.

Based on the principle "Make use of advantages, start up with projects and grow step by step," these development zones have taken full advantage of their resources and have grown in a steady manner. They have already obtained some economic benefits. For example, as of June 1989, the Beijing New Technology Development Zone had approved over 790 new high-tech companies with over 2,600 employees. Approximately 70 percent of these technical people have graduated from college or above. Over 1,600 new high-tech products have been identified. Between January and June 1989, the total revenue was 700 million yuan, the gross industrial output value was 200 million yuan, replacement of profits by taxes totaled 36 million yuan, and 37 million yuan of taxes were paid to the state.

Development zones also promote the reform of the economic system and the S&T structure. The Chinese Academy of Sciences has established 139 new high-tech companies in the Beijing development zone. Over 3,000 scientists and engineers relocated from various institutes to engage in the development, manufacturing and operation of high-tech products.

Based on experience in the West, a way to promote the growth of high-tech business is to establish service centers for technical entrepreneurs. Over a dozen such service-oriented intermediary organizations have been established.

3. High-Tech Management Personnel Trained

High-tech development and management personnel are the key issues in the Torch Plan. Since its implementation, all levels of government have been concerned about personnel training. Over 3,000 people have been trained. In February 1989, the State Science and Technology Commission sponsored the first "training for managers of new high-tech start-up service centers," which received support from the United Nations.

4. Torch Plan Management Gradually Perfected

Various management systems for the Torch Plan are being perfected, including strengthening the management structure, formulating outlines for key development zones and projects, perfecting various reporting and reviewing procedures, and planning the distribution of development zones and service centers. A perfected management system can ensure the healthy development of the Torch Plan.

III. Status and Thinking

Good progress has been made by the Torch Plan. However, we are also facing a new situation. Based on an analysis of the effect, progress, environment and problems associated with the implementation of the Torch Plan, we believe the following development posture will emerge:

—National economic policy, industrial policy and S&T policy will become more and more favorable for the growth of high-tech industry. Overall, the near-term objectives of the Torch Plan may materialize.

—Construction of high-tech development zones will enjoy stable and healthy growth during reorganization and reform. The government is not expected to change its preferential policy toward high-tech development zones. The number of high-tech development zones will not increase significantly. The emphasis is on good management, balanced organization, planning and distribution, and healthy start-up.

—In view of the stability of the opening-up policy and the ability of the opened coastal cities to link the domestic market with the international market, the Torch Plan may have a breakthrough in open cities along the coast. They may become the "beachhead"

whereby inland research institutes, higher-learning institutions and businesses can develop high-tech products, and they will serve as the bases for the expansion of the international investment and technology market into China.

—High-tech industry has a stable period. It should be pointed out that the present reorganization offers an excellent opportunity for high technology and its related products to grow. However, because high-tech products have a limited domestic market and there are special circumstances associated with the creation of the market, the business picture may change if there is a shortage of capital in the economic environment.

—The high-tech product market will change. As the national industrial policy is defined and the industrial structure adjusted, the market for certain high-tech products will shrink and that for other products will not be affected. The products identified to be developed in the five key Torch Plan areas, to be improved after absorption and digestion of imports, and to be used to replace imports have good market potential. The national Torch Plan projects, in terms of investment, development and market, also have good prospects.

In view of the above development posture, in the further implementation of the Torch Plan, we must pay close attention to the following:

Carefully Handle the Relationship Among Project Selection, Environmental Structure and Intermediate Links

The Torch Plan is a directive plan, instead of a project-oriented plan. The major goal is not to complete so many projects in a year; the goal is rather to create small and medium "climates" based on these projects. The so-called "small climate" is an environment in which a specific project may evolve from technology to product to capturing the market. The so-called "medium climate" is one which creates an innovative environment in a larger region.

Regarding project selection: Correct project selection is the starting point and core of the Torch Plan, and is therefore a difficult task. One version of the definition of high technology is that high technology is a comprehensive economic concept. It is a series of closely related technical products, instead of a single project. Hence, the selection of Torch Plan projects not only must consider the technical fields but also its role in providing direction and demonstration.

Regarding the environmental structure: High-tech industries have more demanding environmental requirements. This is the reason why the silicon valleys and the science parks have emerged. Conventional industry does not have these rigorous requirements. The characteristics of high technology created the technology parks and the special features in the technology parks promoted the development of high technology. The creation of this "medium climate" or the construction of a new environment includes the construction of technology parks with preferential treatments; the establishment of entrepreneurial centers to train high-tech talent and to develop high-tech products; the creation of special living accommodations and a cultural atmosphere suitable for high-tech talent; the creation of a venture-capital market; the establishment of a system to protect intellectual property rights; the formation of a wide-ranging, timely, accurate and fast information market; and the founding of organizations to provide consulting services.

If the Torch Plan can escape the traditional project-oriented mode and evolve from pure program management to supporting the creation of a soft environment, in a few years, not only will a number of new products be effectively developed, but also more products will automatically be included in the plan. Consequently, this will produce more economic benefits. The intrinsic advantage of a socialist planned economy not only can effectively push projects forward but also can automatically create a soft environment to suit the objective economic pattern. The Torch Plan can be quite effective in this area.

Regarding intermediate links: During the process of converting technology into products, the intermediate links include: a trial phase between "product development and pilot production" which is affected by a lack of investment vehicle and clear policy, the link between "importing technology and digestion and absorption," and moving a product which is between "production and dominating the market" into that market. These three links are critical to the establishment and growth of a new-technology-based industry, but are relatively weak. Therefore, most technical personnel and development-oriented institutes should work on these issues. In addition, the investment issue has to be resolved. Success in other countries has shown that the investment required in these intermediate phases is 5-10 times higher than that in the research and development phase.

Coordinate Domestic Development With International Efforts

High technology advances at a very fast pace. Hence, it is impossible to develop high-tech products following a closed path. Besides, for a developing nation such as China, allowing international efforts to get involved in our development has the following advantages: 1) It is obvious that there is a definite gap between China and developed nations in conventional technology. However, in certain areas of high technology, we have some opportunities and advantages. These are favorable conditions for exporting high-tech products to generate hard currency and to attract foreign investment. 2) The net result of this approach is to produce a number of management people who know how to run a business, are familiar with foreign trade, and understand international customs. Thus, we can introduce advanced management methods in order to raise the starting point and enhance the effectiveness of development.

The international involvement of high-tech product development in China will take place in many forms:

—Choose a medium or small enterprise in a developed country as the partner to develop a technical product with potential. The "incubated" product is immediately commercialized there and its sales network and management methods are used to enter the world market. Upon successful introduction, mass production begins in China in the form of a joint venture.

—Attract foreign investment with potentially attractive mature results in the form of joint ventures. These will open plants which will bring in advanced management skills and can penetrate foreign markets with existing channels. This is a popular approach.

—Use cheap technical labor and research personnel to develop products for foreign enterprises. This is equivalent to "processing with supplied material" in high technology. The idea is to train people.

—Purchase or merge relevant sales networks abroad. This is equivalent to "buying a ship to sail on the sea." Or, operate foreign sales networks by renting or joint ventures. Or, develop and operate high-tech products with internationally known companies. This is called "borrowing a ship to cross the river."

—Establish "beachheads" along coastal cities such as Shenzhen and Zhuhai to construct research and development bases. Make full use of advantages such as geographic location, human resources and preferential policy to control the pulses of other countries and make these bases a necessary step toward the world market.

The next issue to be resolved in the Torch Plan is the attraction of foreign capital to create conditions for us to enter the world market.

Handle the Relation Between National and Local Torch Plan Projects With Other Technical Programs

The goal of the national Torch Plan is aimed at items that can create a large climate, capable of solving urgent problems facing the nation and forming a better environment. Local Torch Plan projects should take advantage of local resources, technical edges and market potentials. In other national S&T plans, there are high-technology research and development plans, the Spark Plan which faces the needs in rural areas, technology reform plans, technology breakthrough plans, and the Torch Plan. The key to handling the relation between these plans is to make sure they are closely connected in areas such as management and investment.

The Torch Plan has been implemented for 1 year; it has had a good start. We believe that the high-tech torch will burn brightly as the high-tech product development trend is becoming ever more popular.

'Torch Plan' Projects Being Implemented

Beijing Steps Up Efforts

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[Article by Xie Ning [6200 1337] and Han Yuqi [7281 3768 3825]]

[Text] Beijing Municipality has selected the best "Torch Plan" projects based on merit, and has broken the boundary between regions and departments, and between central units and city units. Among the 47 projects of the first group of state and local "Torch Plan" projects for 1989, 16 were from central government units located in Beijing. Among the 19 national-level projects, 13 were from central government units located in Beijing.

The Beijing municipal government has fully recognized the important significance of the "Torch Plan" in the economic and technological development of the capital and has made it an important part of Beijing's industrial development strategy. When the Beijing government delivered the document "Opinions on Organizing Beijing's Torch-Plan Projects" for the municipal science committee to the various units, it requested the units to develop new and high-tech products and enterprises based on unique situations in each unit. In the meantime, it asked departments in charge of finance, commerce, taxes and banking to actively support the implementation of the Torch Plan.

There are many scientific research units of the central government in Beijing; an important consideration for technological development in Beijing is how to make full use of this enormous technological resource and avoid low-level repetition. During the Torch-Plan activity period, a total of 143 projects were submitted by research units of the central government and of the Beijing municipal government. In evaluating the projects, the Beijing municipal committee on science and technology aimed at the goal of developing the local economy and establishing new and high-tech enterprises and broke the boundary between central government units and local government units. It formulated a set of regulations for the Torch Plan projects and conducted a rigorous evaluation based on market forecast, economic benefits, technological level, technical maturity, and the technical and economic level and production capability of the proposing units.

This practice has promoted cooperation between units of the central government and the local government and has laid the foundation for highly technical projects with a high ratio of investment to output. The Haihua New Technology Development Center, in cooperation with the Beijing Municipal Computer Plant No. 3, has developed and produced high performance AT-1204 motherboards. These motherboards are designed and developed by the Chinese themselves for high performance AT-compatible computers. This project, when completed

next year, will improve computer production in China and will produce 500 units per year.

Three Northeast Provinces Receive Bank Loans

[Article by Chen Jingxian [7115 2529 0341]]

[Text] The three northeast provinces are actively pursuing Torch Plan projects. To date, 76 percent of the projects have completed their bank-loan procedures and the remaining projects are applying for bank loans, with the exception of some individual problems.

Since the announcement of the National Torch-Plan Projects in August of this year, the three northeast provinces have responded enthusiastically. Although the shortage of money in the national treasury has brought some difficulties to the plan, the Torch-Plan projects in the three northeast provinces still have achieved encouraging progress under the provincial and municipal leadership and active support of the banks.

In Heilongjiang Province, the slogan "build the province with science and technology" was put forth and the Torch Plan was put on the provincial agenda as a major item. Liaoning Province has incorporated the Torch Plan as one of the unified planning projects and has actively pursued province-wide enterprise evaluations. The Jilin Province Committee on Science and Technology formed a special Torch-Plan Office and has actively pursued project evaluations, loan applications, enterprise development, management regulation formulation, and technical database buildup. The Committee Chairman of the Shenyang municipal committee of science and technology personally led the drive to promote and communicate the significance of the Torch Plan to industrial, commercial and financial sectors.

Despite the shortage of funds in China, the Shenyang Bank of Industry and Commerce has pursued various avenues in raising money for science and technology. They established a science and technology loan department and issued 10 million yuan in bonds to raise 50 million yuan for Torch Plan projects in Shenyang.

Harbin, Changchun and Dalian have all made formal and careful project evaluations. To evaluate 1990 Torch Plan projects, Harbin formulated a set of rules and, using these rules, selected eight projects as national Torch Plan projects from 149 applicants. They used the following criteria to insure a success rate of 90 percent or more for the selected projects: the yearly output value for the project must be greater than 5 million yuan, the profits and taxes must be more than 20 percent, and the payback period of the loan must be less than 2 years.

Problems in Constructing High-Tech Development Zones Reviewed

[Article by Chen Hanxin [7115 3352 2946] of the Shenzhen Science and Industrial Park, Chinese Academy of Sciences: "Problems in Constructing High-Tech Development Zones in China"]

[Text] Abstract:

This paper briefly illustrates the importance of high technology to the development of the national economy. It points out the necessity, feasibility and strategy for constructing high-tech development zones. A three-step construction scheme is proposed.

Key words: High technology, development zone, suit measures to local conditions, rational distribution.

High technology is a new term originating from western countries in the 1970's. In recent years, most people are inclined to believe that high technology represents new and cutting-edge technology that has great military, economic or social impact or has a potential to become an industry.

The current technology revolution is essentially caused by the economic impact of high technology and its associated industry. This technology revolution has raised productivity to an all-time high level, causing profound changes in the economic structure of every country. A large number of high technologies based on modern scientific achievements are emerging. They are concentrated in six areas: (1) electronic information, (2) new materials, (3) new energy sources, (4) bioengineering, (5) marine technology, and (6) space technology.

A high-tech development zone is a multi-purpose base, with a concentration of knowledge and intelligence, whose objective is to develop high technology and new products. It is aimed at encouraging the combining of research and education with production and the promotion of coordinated development between science and technology and the economy and society. In economic geographic terms, it is an area for science and industrial production.

Based on different functions, structures, scopes and features, in other countries high-tech development zones are also called "science parks," "technology parks," "science and technology parks," "research and development parks," "science towns," "technology towns," "high-tech industrial belts," etc. Some are also named after geographic characteristics such as "silicon valley," "silicon hill," "silicon island," "silicon desert," "silicon prairie," and "silicon corridor."

High-tech development zones, as a new economic and social phenomenon, will have a significant impact on high-tech competition, science and technology progress, and the future of mankind.

I. Important Role of High Technology in Promoting Economic Growth

1. High-technology industry, in general, is a leading or strategic industry and plays a vital role in the national economy and defense industry. For instance, the semiconductor is the most important material in an integrated circuit; it becomes the brain of many products and components. The semiconductor industry is the strategic industry that moves us into the era of information. Therefore, its technical level, either directly or indirectly, determines the competitiveness of a number of industries. These industries include electronic communications, computers, machine tools, aerospace electronics, consumer electronics, and robotics. As a matter of fact, it is quite appropriate to consider the semiconductor industry as the "fuel" for high-tech industries.

2. High-tech industries rapidly transform research and development results into products to promote economic growth. For some developing countries, this can push the industrial structure from a labor- and resource-intensive mode toward a knowledge- and technology-intensive mode. For instance, Changyuan Applied Chemicals Ltd., co-founded by Shenzhen Science and Technology Industrial Park Corporation and Changchun Institute of Applied Chemistry of the Chinese Academy of Sciences, uses the "memory effect" polymer developed by the Institute to make radiation cross-linked heat-contraction cable jackets. The characteristics of the material are at world-class level and all the investment has been recovered within two years after it was put in production. In 1988, this 30-man high-tech company produced 5 million yuan worth of products and generated over 1 million yuan of profit. This is a typical example to show how research accomplishments produced by the Chinese Academy of Sciences can be rapidly transformed into high-tech products at the Shenzhen Science and Technology Industrial Park.

3. A high-tech development zone must blend production, research and education together. Technology, industry and commerce must be integrated. The area must be able to attract talented people in order to accelerate the influx of capital to make high technology work at a fast pace. For example, "Silicon valley"; route 128 in Boston; the Sofia-Andipolis Science Industrial Park in Nice, France; and the Hsinchu Science Industrial Park in Taiwan are very successful in this aspect.

4. The zone must create more employment opportunities and train more high-tech people.

5. The zone must promote the growth of the national economy, push for technology reform in conventional industries, and enhance our export capability to bring in more hard currency.

The reason why high technologies can produce such a large thrust on the economy is not only because they are brand new industries that directly generate a great deal of material wealth, but also because high-tech products have great penetrating power. For instance, they have already penetrated into conventional industries such as steel, automobiles, textiles, and light manufacturing, and have resulted in personnel reduction and increased productivity. They have greatly improved labor efficiency, quality and product class, and have enhanced competitiveness.

In the current worldwide economic competition, because of this technology revolution, high technology plays a vital role. Since World War II, the western economy has grown very rapidly. It also relatively smoothly survived two energy crises. One of the important factors is the development of high technology and the establishment of a series of new industries. The U.S. is the pioneer in developing high-tech industries. The revenue of high-tech products produced in the U.S. reached $605.2 billion in 1983. This is 37.9 percent of the total revenue of all products manufactured. Japan, Britain, France and the FRG have also followed the steps of the U.S. in developing high technology and have obtained substantial results. Since 1960, using the electronics industry as the lead, South Korea began developing high technology and realized a high rate of stable economic growth over a long period of time. In 1961, its per-capita gross national product was merely $87. By 1987, it had increased to $2,800. The high-tech industries in South Korea are in electronics, automobiles and machinery. Since 1980, these industries have received preferential treatment from the government and have grown substantially. The proportion of these products relative to the entire gross national product continues to rise. The export value of electronics, automobiles and machinery products reached 30 percent of the total exports from South Korea in 1986. It rose to 40 percent in 1987. Other developing countries and regions such as Taiwan, Singapore and Thailand are making giant strides toward a technology-intensive industrial structure because the development of high technology is being taken seriously.

II. Necessity and Feasibility of Constructing High-Tech Development Zones in China

(1) Necessity

1. From the competitive nature of the world economy and technology, China is situated in a stringent international environment. It desperately needs to strengthen and improve its industrial technical level in order to raise the added value of its export products. We must consider the strategy of using high technology to find a breakthrough in the world market, to promote the development of conventional industries, and to improve China's industrial technical level as a viable option. The construction of high-tech development zones is an effective method for realizing this option.

2. The construction of high-tech development zones will facilitate our current industrial structure reorganization. On one hand, the technical level in the industrial structure is outdated and technology reform is urgently needed. On the other hand, regional economic vitality in the present industrial structure is insufficient and needs to be revitalized. The technology development zones can effective drive up the local economy.

3. To properly handle the construction of high-tech development zones is an effective way to reform our economic and science and technology structure and to combine technical and economic construction together.

4. High technology will control competition in the 21st century and high-tech development zones will be a front line in gaining this type of control. Only if we construct these high-tech development zones in time will we be able to create more opportunities for innovation and to provide more conditions to catch up with the rest of the world.

(2) Feasibility

1. Since the liberation of China, the government has systematically planned and constructed knowledge-intensive areas, primarily centered around science and education, in some cities. They provide the critical prerequisites for constructing high-tech development zones in China. In terms of geographic environment, technical talent, technical instruments and equipment and technical information, these knowledge-intensive areas have advantages no other developing countries can offer.

2. Although the overall industrial-production development level in China is lagging behind that of developed countries in the world, after over 30 years of large-scale industrial buildup, especially as a result of importing a great deal of advanced technology and equipment in the past decade, the technical level in some local areas and in certain industries has reached world-class level. There is a considerable base of high-tech-related industrial facilities to produce high-tech products.

3. The reform and opening up policies have provided a favorable social environment for constructing high-tech development zones in China.

4. China has a large number of competent scientists and engineers. In certain disciplines, we are close to or already at world-class level. We have the technical support necessary to participate in international technical and economic competition.

III. Strategy for the Construction of High-Tech Development Areas

(1) Put construction of high-tech development areas in a strategic position.

Since 1980, pushed by the tide of the new-technology revolution, every developed country announced new high-tech projects to further advance high-tech industries, which made the competition fiercer. For example, the U.S. began the "Star Wars" project in 1983. Immediately afterward,

Japan followed with its "Basic Policy for the Promotion of Science & Technology" in 1984. Western Europe introduced the "EUREKA Program" in 1985 and Russia and eastern Europe revealed the "Comprehensive Guideline for Scientific and Technical Progress" in 1985. In recent years, Asian and Pacific region countries are also actively pursuing high-tech industries or building science and industrial parks. Furthermore, government intervention has intensified and large sums of capital have been poured into high-tech development. Developed countries are spending approximately 2-3 percent of their GNP on research and development, most of it on high technology. For instance, U.S. industries spent $US60.75 billion on research and development in 1983, and ¾ of it was used for high technology. The fact that developed nations that already have high-tech advantages are still trying to strengthen their high-tech development trend has to be taken seriously by us.

According to statistics, China has 3.4 percent of worldwide trade, but the export of high-tech products is less than 0.5 percent of the total export of high-tech products worldwide. In 1987, we spent 1.19 percent of our GNP on research and development, less than one-half the proportion in developed countries. Furthermore, our system causes major links such as research, development, industrialization and commercialization to be out of synchronization. On top of that, due to departmental and regional division, funds have been spent in a scattered manner. These factors are affecting the efficient utilization of capital. Therefore, how to use limited funds to pick up the pace of high-tech development becomes an urgent research issue.

More and more people are realizing that the vitalization of China will have to rely, in part, on reform, and also on advances in science and technology, particularly high technology. On the basis of low technology, it is impossible to build the framework for a modern super nation to make a developing nation rich and prosperous in the near future. Therefore, developing high-tech industries must be placed in a strategic position. Effective measures must be taken to accelerate the development of high-tech industries.

(2) Analysis of the strategy for developing high-tech development zones

Although high-tech development zones have been around for decades, China just recently began taking action to cautiously plan for the construction of these zones, under the guidance of the present reform and opening up policy of the Chinese Communist Party. In the overall technical and economic level, there is a large gap between China and other industrialized countries; hence, the planning and construction of high-tech development zones must "stand alone in China to face the world." In other words, we have to take this rigorous challenge into account when we construct our high-tech development areas, based on the magnitude of high-tech revolution from a worldwide perspective. However, we must also take China's special situations into consideration and cannot blindly copy the high-tech parks

of other countries. Instead, we have to determine our own path to create a new model to suit the special situations in China.

Based on this understanding, the construction of high-tech development zones should obey the following strategic guideline: to make use of advantages in a vigorous and steady manner, to stress key points to suit local needs, to identify levels and support better choices, to make sure of a reasonable geographic distribution, and to be practical and proceed step by step.

1. Utilize advantages in a vigorous and steady manner. We should encourage people to construct high-tech development zones using different ways and models. First, each zone has different conditions, characteristics and advantages. Therefore, it will have different development methods. There may be various types of high-tech development zones throughout the country. We should actively encourage these approaches. Next, as we continue our reform effort, China's economy is also becoming diversified. In view of this situation, we should encourage all kinds of ways—including investment by local government, entities and individuals—to construct high-tech development zones. The idea is to introduce competition into the construction and development of industrial parks to speed up the progress.

2. Identify focal points to suit local situations and sort out priorities to support better choices. Many regions are preparing to construct high-tech development zones. This is a good sign; however, in order to prevent confusion and waste, the central government should have an overall plan to allow us to sort out different levels and choose the better ones to support. In particular, several key points must be identified and the central government should choose some areas to provide direct support. These areas, on one hand, can serve as demonstration sites. Moreover, with concentrated effort, success can be ensured. This will provide a great push for the development of high-tech industry in China. Furthermore, the construction of high-tech development zones must be focussed on key points that coincide with the strength of the region in order to realize economic and social benefits as soon as possible.

3. Give consideration to a fair geographic distribution and be practical and proceed in a step-by-step manner. Based on incomplete statistics, 17 cities, including Beijing, Tianjin, Shanghai, Wuhan, Guangzhou, Shenzhen, Nanjing, Changchun, Shenyang, Dalian, Xian, Lanzhou, Chongqing, Chengdu, Hefei, Fuzhou, Xiamen and Haikou, either have constructed or plan to construct high-tech development zones. Hence, from the overall distribution, we have to give consideration to all geographic areas. Based on present local conditions, areas that have the resources to build high-tech development parks can be divided into three categories: (i) Knowledge-intensive areas. These areas are usually in or near large cities with advantages such as talent, technology and information. (ii) Research and development bases or industrial bases for defense-related or high-tech industries. These areas have the associated industrial facilities and

technology base. In addition, workers have a higher technical level and quality which helps the development of high-tech industry. (iii) Cities along the coast that are opened to the outside world. Because of the open policy environment and good geographic location, these areas can attract foreign investment and advanced foreign technology. Furthermore, they serve as a window for the rest of the country to expand the exchange of technology with other nations. We must have a feasible plan for these three categories of zones and cannot allow everyone to rush into mass action. We have to proceed in a step-by-step manner to construct high-tech development zones to suit the needs of the national economy.

IV. Rational Distribution of High-Tech Development Zones in China

(1) Conditions for site selection and distribution of high-tech development areas

Experience in other countries has proved to us that the premise of constructing high-tech development zones is distribution and site selection. Whether the distribution is reasonable and the site selection is correct is an important factor in ensuring the successful development of high-tech items. To a large degree, it even determines the fate and future of the high-tech development zone. What, then, are the conditions to consider?

1. A high-tech development zone should use the knowledge base of an institution of higher learning or research institute as its technical support. Therefore, it should be located near a knowledge-intensive area.

2. The city should have a good industrial base and the capability to develop new technology.

3. The city should have a flexible policy to attract investment, technology and people.

4. The site should have adequate basic facilities and good transportation and communications means.

5. The site and its surroundings must have a good natural and social environment.

6. The site must have sufficient room for near- and mid-term growth and it will have an impact on the transformation of conventional industry in the region.

(2) Distribution of High-Tech Development Zones

Propelled by international economic cycles and the new-technology revolution, some provinces and cities have planned to construct high-tech development zones since 1983. Good progress has been made in the following areas: the Beijing Zhongguancun Experimental New-Technology Development Zone, the Shenzhen Science and Technology Industrial Park, the Shanghai Caohejing Microelectronics Development Zone, the Wuhan Donghu High-Tech Development Zone and the Tianjin Nankai Science and Industry Park. Other areas such as the Nanjing Jiangsu Science and Industry Park, Xian

Nanjiao Science and Industry Park, Changchun Nanhu-Nanling High-Tech Development Zone, and Shenyang Nanhu Science and Industry Park are in the planning stage. In addition, Chengdu, Chongqing, Lanzhou, Hefei, Fuzhou, Xiamen, and Haikou are also considering problems associated with the construction of high-tech areas.

In order to help us analyze the industrial base and technical strength of the cities mentioned above to determine the focal points and priorities to provide support for the construction of high-tech development areas, Table 1 has been prepared for reference.

Table 1.
A Statistic Diagram of Urban Population, Gross Industrial Output Value and Scientists and Technicians of 17 Cities of China, 1986

	Popula-tion (10,000)	Gross Indus-trial Output Value (10,000 yuan)	Output Value per Capita (yuan/person)	Scien-tists and Engi-neers	Number of Scien-tists and Engi-neers per 10,000 People
Coastal Open Cities					
Dalian	168.21	943971	5611.86	50649	301
Shen-yang	428.50	1782693	4160.3	160892	375
Tianjin	545.92	3065122	5614.6	211709	388
Beijing	596.80	2958343	4957.0	360861	604
Shanghai	710.16	6777405	9543.5	374256	527
Nanjing	228.89	1129322	4933.9	117728	514
Fuzhou	120.50	376235	3122.3	16270	135
Guang-zhou	335.92	1530174	4299.20	54058	161
Special Eco-nomic Zones					
Shen-zhen	25.74	311104	12086.4	9476	368
Xiamen	55.84	233977	4190.1	9698	173
Haikou	30.03	39248	1326.9	2502	83
Inland Cities					
Wuhan	349.26	1550583	4456.8	142043	407
Xian	238.69	765938	3208.9	30340	127
Chengdu	264.24	797096	3016.5	116237	440
Chang-chun	190.90	608350	3186.7	92544	485
Chong-qing	283	980014	3463	100562	355
Lanzhou	139	580456	4176	46662	335
Hefei	90.0	336837	3743	56798	631

Based on Table 1 and other conditions, a three-level distribution plan is introduced here for consideration.

1. Among coastal open cities, special territories and inland cities, let us choose Beijing Zhongguancun and Shanghai Caohejing, Shenzhen Science and Technology Park, and Wuhan Donghu, respectively, as key national high-tech development zones and provide special support. The main reasons are: relatively the overall conditions in these four places are more superior. They have already started and are making good progress. There is a base there already so the government does not have to make a large investment. It primarily will provide supportive policy and planning guidance. Moreover, these four areas not only represent the three different models we have but also are rationally distributed geographically. From a long-term perspective, they will have a significant impact on promoting the development of high technology and creation of a economies of scale in China.

2. Choose Tianjin, Shenyang, Nanjing, Guangzhou, Chengdu and Xian as six major experimental sites for constructing high-tech development zones. These areas are expected to be constructed primarily with resources gathered by local government and economic entities.

3. For areas that are not experimental sites at the present time, the government should formulate plans to guide the development in a step-by-step manner to avoid a rush. In addition, if the local area has the initiative, and has sufficient human, financial and material resources, the local government may try to construct a high-tech development zone that is closely tied to the local economy as long as it does not become a burden and affect the revenue on the local level. For example, Xiamen has built a biotechnology park, Hainan has established the Hainan Science and Industry Park in Haikou, and Fuzhou plans to build a park on a 0.4 km² piece of land in the Mawei economic development zone. Most open cities along the coast have set up technology and economic development zones. We can use the facilities in these development zones to construct new technology centers and use them as the seeds for high-tech development zones. On the other hand, it may also be feasible to utilize the favorable conditions in universities to create nurseries for science or industry.

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CAS President Zhou Guangzhao Quoted at 1990 Work Meeting

On S&T for Economic Development

90CF0227C Beijing KEJI RIBAO [SCIENCE AND TECHNOLOGY DAILY] in Chinese 16 Dec 89 p 1

[Article by Huang Yong [7806 0516]]

[Text] The Chinese Academy of Sciences opened its 1990 work meeting in Beijing today. President of the Academy Zhou Guangzhao [0719 0342 0664] pointed out in his report, entitled "40 Years of Pursuit and Exploration," that S&T is the hope for economic development.

Zhou said that China is a large country that faces unprecedented difficulties due to a backward economy, a heavy burden of population, a shortage of per-capita natural resources, and a deteriorating environment. It is highly significant to promote social development by relying on science and technology. The science and technology profession is duty-bound to treat S&T as a primary production force and apply S&T to industrial and agricultural production, policy making, and resource utilization.

Zhou said that it takes a large S&T force to achieve modernization in science and technology. Millions of S&T workers in China, cultivated over the years by the Party and the state, have become a valuable force in China's socialist construction. We must use our successful experience of the past and continue to expand on the superiority of socialism. Money, manpower and resources should be used in the most critical areas. Low-level repetition should be avoided, and the national research institutes should assume a central role.

Zhou said that we must follow the rule of S&T development, that is, S&T research must be perfected from two fronts: the demands of S&T development itself and of social progress, and the demands of economic development. The two different tasks should be pushed forward simultaneously using different operating mechanisms, standards of value and management systems. He reiterated the CAS's policy of stressing both S&T development and serving the national economic development. He proposed a 3:3:4 ratio for developing S&T research, that is, 30 percent of the resources will be devoted to basic research and tracking of high-tech developments; another 30 percent of the resources will be devoted to work on natural resources, ecology and agriculture; and the remaining 40 percent will be used in engineering technology.

Climate of Open Debate for S&T Proposed

90CF0227D Beijing KEJI RIBAO [SCIENCE AND TECHNOLOGY DAILY] in Chinese 17 Dec 89 p 1

[Article by Huang Yong [7806 0516]]

[Text] In a recently held work meeting of the Chinese Academy of Sciences, President Zhou Guangzhao of the Academy advocated mobilizing S&T personnel under the overall goal of developing S&T in China and making China a stronger nation through the four modernizations.

Zhou pointed out that S&T is a creative endeavor and to a large degree relies on the initiative of the S&T workers; it is therefore necessary to mobilize S&T personnel.

To mobilize S&T workers, Zhou said, we must first properly carry out the party's policy concerning intellectuals and trust the intellectuals politically. The intellectuals are a part of the working class, their devotion to the S&T enterprise of the socialist motherland should be sufficiently recognized. In the meantime they should be made to understand the unique situation in China and the urgent needs in China's modernization. The intellectuals should be encouraged to join the effort of reform and construction based on their own objective considerations.

Zhou also pointed out that creating an academic environment of free expression is an important step toward mobilizing the initiative of the S&T personnel. In the Chinese history, criticism of Ma Yinchu's new theory on population, Morgan's genetic theory, Pauling's resonance theory, and criticism of psychology as idealism have gravely affected China's development in science and technology and social economics. We must learn from these lessons and have respect for knowledge and talent. Let the scientists discuss the academic issues and reach a consensus and accept the truth. Never replace academic voices with political slogans and avoid administrative interference. Zhou also called for better working and living environments for S&T personnel.

Measures To Develop, Plan, and Administer National Key Industrial Technologies

90CF0330B Tianjin ZHONGGUO JISHU SHICHANG BAO [CHINA TECHNOLOGY MARKET NEWS] in Chinese 20 Jan 90 p 1

[Article by Gao Ren [7559 0086]: "Measures To Develop, Plan, and Administer National Key Industrial Technologies Announced"]

[Text] In order to put the management of national key industry and technology development plans on track, the State Planning Commission recently issued "Measures To Administer the National Key Industrial Technology Development Plan" and has already begun implementing it. It primarily applies to large and medium-sized national enterprises and first- and second-class national industries.

S&T planning is an integral part of the plan for economic growth and social development. The development plan is a major part of the national S&T plan which is linked to technical efforts and pilot production. Along with technology import, technology transformation and basic construction, it forms a complete set of directive plans. The objective of preparing a development plan is to mobilize the enthusiasm of large and medium industries to engage in development, to enhance their technical ability to develop new products, and to develop new products and technologies that meet high technical standards level, generate great social and economic benefits, and are in demand in the market place. This is accomplished through economic and administrative means

such as planning, finance and credit. In addition, it also promotes the rational adjustment of the product structure and industrial structure. The technical development covered by these "measures" includes the design and development of products, techniques, and facilities based on applied research or imported technology in order to result in the manufacturing of products or related technologies. The document is divided into five chapters and 26 articles, including general principles, preparation methods, organi. ntion, capital management and appendix.

The principle of technical development, as specified by the "Measures," involves the consolidation of efforts by industries, research institutes and higher-learning institutions centered around initial cooperation across different sectors of industries and regions. Repetitive development of low-level prot ucts must be avoided. Digestion and absorption of imported technology should be the primary means to realize domestic production of products and equipment; it is also the link between independent development and international cooperative development, including many kinds of secondary development. By focusing on the product, by taking technology as a foundation, and by starting with raw materials, basic components, subassemblies and even entire machines, complete sets can be developed. Let the market be our lead and focus for improved economic benefits. Let us aim at world-class level and zoom in on weak key issues in industrial production technology in order to push our products into a new generation, and to raise the level of products and technologies.

The conditions to create a project in the development plan include products and technologies that can lead the industry forward, that can put us in the lead, that can upgrade existing facilities to a new generation and have a wide range of applications, that can significantly conserve energy and materials in order to lower costs, and that can replace imports, or penetrate the world market, or can generate large output value and profits and taxes, or can earn or save hard currencies. In addition, there are six conditions under which a project may be cancelled.

It is also pointed out in the "Measures" that the government encourages the transfer of development results with compensation. The income belongs to the development unit. Specifically, it should follow the "Rules Governing Technology Transfer" issued by the State Council. Unless exempted by the government (ministry or commission), the development unit has no monopoly over the results. Development units may enter their results for the outstanding national new product award or other national technical awards, and they may also apply for a patent. As for the people responsible for the project, the development unit should reward them based on the rules and regulations issued by the relevant authority.

Different ways may be used to raise funds required for the development project. Working capital primarily consists of money raised internally by the industry itself, subsidies provided by the government, and subsidies provided by the organization in charge.

The "Measures" also points out that development plans will be formulated by the State Planning Commission in conjunction with the industrial and transportation department of the State Council and the economic commissions of various provinces, autonomous regions, cities with independent economic authority and other cities included in the plan. Project status will be reviewed twice a year (in March and September) and a summary will be sent to the S&T office of the State Planning Commission. Based on the principles of this document, all departments and regions may formulate measures to administer their development plans by taking their specific situations into consideration.

Science Achievement Extension Plan Drawn Up

40101015A Beijing XINHUA in English 24 Feb 90

[Text] China has drawn up a plan to spread the latest scientific and technological research findings throughout industry and agriculture. The plan was formulated by the State Science and Technology Commission and will be put into effect this year. It was tried last year on 40 major projects of 5 types at a cost of nearly 300 million yuan. It disseminates major technologies in agriculture, energy, machinery, and petrochemical and light industries.

The projects included in the formal state plan issued this year are of two levels—state and provincial. In a ldition to those attempted last year are 100 industrial and agricultural projects. Funding has also been increased.

The plan includes some of the major projects included in the state's "Spark Plan," designed to boost China's agriculture.

It is expected that, after 3 years, the industrial projects will create an annual output of 18 billion yuan and the agricultural projects will yield an output of 6.5 times the investment.

The plan places particular emphasis on agriculture, energy, raw materials, transportation, communications and large- and middle-scale enterprises. Key projects include those to develop high-yield crops and to save power and raw materials.

This plan now joins five other plans to develop China's science and technology in comprising a complete system. The others include the plan to tackle key scientific problems, the "Spark Plan," the high-tech research plan, the "Torch Plan" to develop high-technology industries and the basic research development plan.

First Human Embryo Refrigeration Bank Established

40101014A Beijing XINHUA in English 2 Mar 90

[Text] China's first refrigeration bank for human embryos was set up recently at Changsha Medical University, Hunan Province.

According to Professor Lu Guangxiu of the university, the technique, which preserves embryos in liquid nitrogen at -196°C, has been mastered by only a few countries so far.

Up to now, 36 embryos produced from external fertilization and belonging to 18 couples are stored in the bank, one of which has been under refrigeration for 14 months.

Liaoning Becomes Major Chemical Industrial Base

40101014B Shenyang LIAONING RIBAO in Chinese 22 Dec 89 p 2

[Excerpts] Guided by the policy of reform and opening defined by the 3rd Plenary Session of the 11th CPC Central Committee, Liaoning Province's chemical industrial production has developed steadily, with its economic efficiency improving constantly. With its relatively complete chemical industrial system that embraces the categories of chemical minerals, basic chemical industrial raw materials, chemical fertilizers, pesticides, organic chemistry, synthetic materials, precision chemical industry, rubber processing and chemical industrial machinery, Liaoning Province has become one of China's important chemical industrial bases.

There are more than 100 large and medium-sized chemical industrial enterprises in Liaoning, which is more than any other province has in China. According to the statistics compiled by the Ministry of Chemical Industry in 1987 for the 280 major chemical industrial products, Liaoning Province ranked first in China in producing 50 of these products. In each of the years since then, the state has transferred 1.4 million tons of chemical industrial raw materials, representing 73 categories, out of Liaoning, demonstrating the extremely important role it plays in supporting China's four modernizations.

A number of large and medium-sized chemical industrial enterprises have conducted technological transformations, and some old enterprises still radiate vitality. The 21 projects, each with an investment of 5 million yuan, which were completed during the Seventh Five-Year Plan period, have not only gained more momentum for the further development of enterprises, but have also changed the structure of the products.

During the Seventh Five-Year Plan period, the chemical industrial enterprises in Liaoning Province exercised reasonable utilization of petroleum and natural gas resources.

The pace of export-oriented economic construction has been accelerated. So far, chemical industrial enterprises in Liaoning have imported 139 technologies valued at $325,100. There are currently 16 Chinese-foreign joint ventures, cooperative enterprises, and foreign-funded enterprises in the chemical industry field, with the total investment reaching $76,700 [as published]. Along with importing technologies, these enterprises have also vigorously produced competitive products for export. Tires, rubber-soled shoes, pesticides, and organic chemical raw materials have been exported in a steady stream to more than 30 countries and regions in Europe, America and the Asian-Pacific region. Liaoning Province has already earned more than $100 million in foreign exchange from the exports of these products, exceeding the total sum attained during the Sixth Five-Year Plan period.

Chemical industrial enterprises in Liaoning Province have adopted new technologies and the production structure of these enterprises has become more rational. Through technological importation and development, chemical industrial enterprises in Liaoning have accelerated the renewal and upgrading of their products. The rate of quality products has increased by 24.12 percent over that in 1980, and the proportion of the precision chemical industrial product output value in the total output value has risen from 20 percent in 1980 to the current 30 percent. More than 360 products have been awarded the title of quality product by the Ministry of Chemical Industry and Liaoning Province.

Application of Oligonucleotide-Directed Mutagenesis to Making Deletion Mutation

40091009A Beijing YICHUAN XUEBAO [ACTA GENETICA SINICA] in Chinese Vol 17 No 1, Feb 90 pp 63-69

[English abstract of article by Wei Nan [7614 2809], Qin Ning [4440 1337] and Li Yuyang [2621 5148 7122] of the Institute of Genetics, Fudan University, Shanghai; Wu Shengming [2976 5110 2494] of the Department of Molecular Genetics, Second Military Medical College, Shanghai]

[Text] By means of oligonucleotide-directed mutagenesis, the authors made 27bp and 18bp deletion at the junction region between the α-factor signal sequence and α-hANP [α-human atrial natriuratic peptide] gene, and the α-factor signal sequence and α-IFN [α-interferon] gene, respectively. Since the deleted region contains one HindIII site, mutants lacking this site were selected. The results of DNA sequence analysis show that the mutant sequences were the same as had been designed.

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Isolation of DNA Fragment H8 Promoter Function From *Aspergillus Foetidus*

40091009B Beijing WEISHENGWU XUEBAO [ACTA MICROBIOLOGICA SINICA] in Chinese Vol 30 No 1, Feb 90 pp 16-21

[English abstract of article by Liu Hongdi [0491 1347 6611], et al., of the Institute of Microbiology, Chinese Academy of Sciences, Beijing; Cao Xu [2580 2485], et al., of the Institute of Virology, Chinese Academy of Preventive Medicine, Beijing]

[Text] A DNA fragment H8 promoter function containing H8 was isolated from the genomic DNA of *Aspergillus foetidus* by using a promoter cloning plasmid pJGI which generally functions in both procaryotic and eucaryotic cells. Southern blot demonstrated that the H8 fragment was from *A. foetidus*. DNA sequence data showed that the H8 fragment has 750bp, containing a typical "TATA box" and an enhancer-like sequence GTGGTT^C_A. Primary experiments have confirmed that the H8 fragment is functional not only in *A. foetidus*, but also in *E. coli*.

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Membrane Components of *Shigella Flexneri*, Relationship to Bacteria Antigenicities, Virulences

40091009C Beijing WEISHENGWU XUEBAO [ACTA MICROBIOLOGICA SINICA] in Chinese Vol 30 No 1, Feb 90 pp 48-53

[English abstract of article by Jin Ling [6855 7227] and Su Xin [5685 2450] of the Institute of Microbiology and Epidemiology, Academy of Military Medical Sciences, Beijing]

[Text] The authors' previous works have shown that the membrane proteins of *Shigella flexneri* can elicit protection against the bacteria *in vivo*. In this paper, using human convalescent sera (HCS) from adult patients infected with *S. flexneri*, the authors investigate the relationship between membrane components of *S. flexneri* and their antigenicities and virulences. It is shown by immunoblotting that five virulent strains of *S. flexneri* and the avirulent strain T32, derived from *S. flexneri* 2a by Istrati in Romania and used as a live vaccine, had three common protein bands formed by the MW components67kD, 63kD and 60kD with either the HCS from patients infected with *S. flexneri* 2a and 3a or that absorbed by an avirulent variant strain 24570 of *S. flexneri* 2a, while the virulent strains M90T and M25-8A (pWR110) miniI showed two other MW bands, 78kD and 35kD, respectively. In contrast, no band was found with strain 24570. The HCS from patients infected with *S. flexneri* 1a, 2a and 3a, as well as that absorbed by 24570, demonstrated a blocking effect on the invasiveness of the virulent strain of *S. flexneri* to the kerato conjunctiva of guinea pigs, while the HCS absorbed by T32 lost the blocking effect, accompanied by the disappearance of the 67kD, 63kD and 60kD components, when T32 was used as an antigen, indicating that the 67kD, 63kD and 60kD membrane components of *S. flexneri* may account for the *S. flexneri* antigen's eliciting protection antibodies *in vivo*. However, the HCS absorbed by T32 did bind the 67kD, 63kD and 78kD, 35kD components of M90T and F2a-12, suggesting that in the 67kD and 63kD bands, two kinds of components exist that have the same molecular weight but different antigenicities, one of which may account for the protection antigens and the other, together with the 78kD and 35kD components, corresponding to the determinants of the virulence of *S. flexneri*. Further studies using minicell cultivation and autoradiography demonstrated that the membrane components reacting with the HCS in the virulent strains of *S. flexneri* were plasmid coded.

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Snake Venom Differentiation by "Rocket" Immunoelectrophoresis

[English abstract of article by Li Biqing [2621 4310 2532] and Cao Jinhong [2580 6855 7703] of the Institute of Pharmacology and Toxicology, Academy of Military Medical Sciences, Beijing]

[Text] A method for snake venom differentiation by "Rocket" immunoelectrophoresis is described. The method has been used to differentiate venom from different species of snakes according to the patterns of the "Rocket" peaks, achieving reliable results. It shows a linear range of from 0 to 2.8 µg/ml, and the suitable concentration for the snake venom concentration is 3.0 µg/ml.

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hMT-Ia Gene Used as Selective Marker to Express HBsAg in BPV Vector

[English abstract of article by Wen Xiaoyuan [3306 2556 3601], Ruan Li [7086 0500], and Ren Guifang [0117 6311 2455], of the Institute of Virology, Chinese Academy of Preventive Medicine]
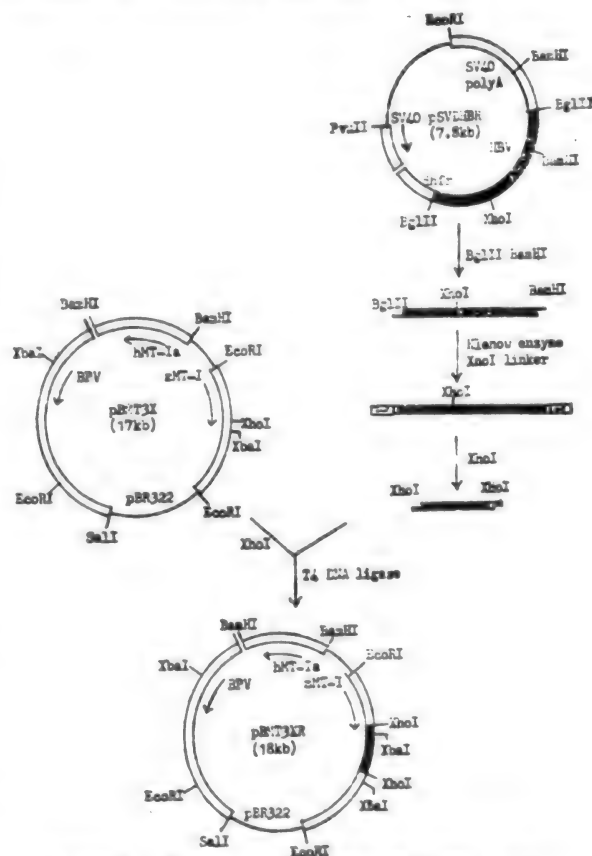
Figure 1. Construction of Plasmid pBMT3XR

[Text] A hepatitis B surface antigen gene was fused with a mouse MT [mettallothionein] promoter to construct the pBMT3XR plasmid. Using the Calcium Phosphate Precipitation technique to transform C_{127} cells with this plasmid, HBsAg was expressed. The experiment also confirms that HBsAg expression can be induced by cadmium.

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Isolation, Purification of Anti-Morphine Peptide from Dog Brain, Its Identification

[English abstract of article by Liao Zhurong [1675 0504 2837], et al., of the Department of Biology; Chen Yuzhen [7115 3768 3791], et al., of the China-Japan Friendship Institute of Clinical Medical Science]

[Text] A pure peptide has been obtained from a dog brain. The entire dog brain was homogenized and extracted with 0.1 M acetic acid. The extract was centrifuged at 15,000 g for 30 minutes. The supernatant was lyophilized and the residue was dissolved in 0.1 M acetic acid and was allowed to go through the Sephadex G-50 column twice and the CM_{22} cellulose and Sp-Sephadex C-25 ion exchange column. The sample obtained was applied to a HPLC (0.5 x 30 cm) with cross linking (3-10 μ). The sample is referred to as the 74a peptide, and exhibits only one band on SDS-polyacrymid gel electrophoresis or isoelectric focusing. Its isoelectric point is around pH 7.5, and M.W. is approximately 10,000 daltons. The sequence of the N-terminal 35 amino acid residue has been determined. The 74a peptide, which is a new peptide, exhibits significant anti-morphine activity.

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Details Provided for New High-Speed Computers, Special Hardware

Systolic-Array Computer Developed

90CF0178A Beijing JISUANJI SHIJIE [CHINA COMPUTERWORLD] in Chinese No 43, 8 Nov 89 p 1

[Article by Shao Xiangqian [6730 0686 0467]: "Research on China's Systolic Array Computer Reaches Major Breakthrough"]

[Text] A Systolic Array Computer, designed and manufactured in China to an international standard of the mid-1980's, recently went into operation at Institute 709 of the China Shipping Corporation, its developmental unit.

This computer has been given the name 980 Star Systolic Array Computer, and it uses the systolic-array technology that began in the late 1970's and that utilizes a parallel-pipelined architecture, directly executing one or more kinds of algorithms in hardware. This computer is made up of 16 array cells having independent calculation functions, which then constitute a two-dimensional 4X4 square matrix having such features as being duplicable, programmable, and expandable. With the Intel series of computers as host machines, they form multi-level parallel general-purpose computing systems. In this system, the speed of the 980 Star can reach 10 MIPS [million instructions per second], and peak calculation speed for the arrays is 160 MIPS.

The 980 Star can act as a hardware accelerator to directly execute algorithms for the host machine, and its system software includes management programs, driver routines, and control programs on interface processors resident in the main controller; it provides the user with many callable common library functions; and it has an entire set of microcode development tools for developing functions. Under the Intel 310 expansion iRMX operating system, the user may directly call library functions as part of application programs, using PL/M-86.

According to the designer of this computer, Professor He Guo [0149 0948], this machine provides an internationally advanced systolic-array computer to users in research, engineering, and applications fields who are in urgent need of it. They can add to the function library, increase the number of development tools, and can use it to form user-expandable systems. It also has the capacity, over the years, to transform the interface and software, allowing this 980 Star to work with different kinds of computers.

CAE Workstation for LSI/VLSI

90CF0178B Beijing DIANZI SHICHANG [ELECTRONICS MARKET] in Chinese 13 Nov 89 pp 1, 2

[Article by Zheng Shilong [6774 0013 7127] and Tian Jingying [3944 1166/7230 3841]: "The Kejian Company Develops the Kangfa Series of CAE Workstations"]

[Text] In an effort to promote expeditious transformation of science and technology into productivity, the China Kejian [4430 0256] Company, Ltd.—an industrial base for high science and technology that brings together research and development with production management—has come into being. In operation for more than a year now, the Kangfa [1660 4099] series of CAE [computer-aided engineering] workstations developed by this company has racked up sales of 53 units domestically, which has saved the state US$5 million. According to an expert evaluation organized by the State Science and Technology Commission, this product is of an advanced international level, and it has overcome the embargo on LSI/VLSI CAE technology by certain Western nations. It is also the first practical electronic CAE workstation developed and manufactured in China that combines software and hardware.

With the constant increase in the complexity of systems engineering for computer and communication systems, and the dramatic development of semiconductor technology, the design of LSI and VLSI circuitry is in desperate need of computer-aided engineering workstations. To this end, the China Kejian Co., Ltd., which is affiliated with the Chinese Academy of Sciences (CAS), in cooperation with units at the CAS Institute of Computing and the CAS Microelectronics Center, with the vigorous support of the State Science and Technology Commission and the State Planning Commission, began development work in 1985 and finished a prototype in only 11 months. This prototype was quickly made available to the domestic market. From product development to testing, batch production, and marketing, and again from in-depth research and secondary development based on data from the marketplace, these things have joined to constitute a favorable research mechanism, allowing the organic integration of research achievements with economic construction.

The China Kejian Company has now developed and produced more than 50 of the Kangfa 1-6 series of CAE workstations. This series is provided with abundant application software, has such functions as graphics input, logic simulation, time-sequence verification, circuit emulation, fault simulation, and verifiable analyses. With these functions can be accomplished completely custom master drawings, gate-array-chip circuitry design, printed-circuit board design, design for PLA [programmable logic arrays], and the design of standard blocks. And it is also capable of mask analysis and master-drawing verification and I/O format conversion. It has a good performance-to-price ratio, and it has achieved genuine practicality and complete engineering capability.

The China Kejian Company is quite cognizant of after-sales service, and has dispatched a powerful technical contingent to provide training for technical personnel free of charge. For all customers in need of repairs, there will be a response within a week, and technical consultation can be had at any time. The Kangfa series of CAE workstations have already been sold to Qinghua University, Beijing University, Fudan University, Xian Jiaotong University, the Hangzhou Institute of Electronic Engineering, and Institutes 54, 38, and 24 of the Ministry of Machine-Building Electronics Industry (MMEI),

as well as to various institutes within the Chinese Academy of Sciences. Using this equipment, users have developed a number of LSI ASIC's, printed circuit boards, and CMOS gate arrays with macro-element bases. Among products using these gate-array designs are an 800-gate 3-micron CMOS gate-array series of automatic-washing-machine control circuits, a 1500-gate 1.5-micron CMOS gate-array signal processing system, a 500-gate 3-micron CMOS gate-array electronic clock, a program controller, a time-sequence allocation controller, and a data-channel allocator.

And finally, the Kejian Company is preparing to work with MMEI's Institute No 6 to better disseminate CAD technology. This hardware has led to the development of the Huasheng 3/60 products that are completely compatible with Sun workstations. These are general-purpose workstations for applications in 10 major fields, including machinery, construction, office automation, geologic and petroleum exploration, software engineering, and structural analysis. We can look forward to a high S&T industrial base that will come out of the Kejian Company at Shekou in the Shenzhen Special Economic Zone.

New Imagery Computer for Air Force

90CF0178C Beijing JISUANJI SHIJIE [CHINA COMPUTERWORLD] in Chinese No 44, 15 Nov 89 p 14

[Article by Li Guoqing [2621 0948 3237]: "The MCGI-I Small Imagery Computer"]

[Text] The MCGI-I small imaging computer developed by an Air Force aeronautics institute passed its technical evaluation recently in Harbin. This computer uses two TMS32020 chips to make an imagery computer that has a dual bus, multiple ports, and parallel processing. It is primarily for use in generating and displaying three-dimensional controllable targets in the air or on the ground in real time, and it is capable of handling 250 3- or 4-point surfaces. The computer receives TTL [transistor-transistor logic] level-control signals, and outputs standard visible signals. The primary clock speed is 40 MHz; field frequency is 25 frames per second, there are 16 shades of gray; overall processing speed is 26.25 MIPS; resolution is 512X512 pixels; and target size and attitude can be changed at will by control signals.

The MCGI-I combines software and hardware, completely implementing in hardware such segments as image filling that involve many operations and much repetition. Software handles such segments as coordinate transforms, blanking and masking, and sequencing of gray-level calculations for a variety of target models; these models must be switched for different application sites and require complex calculations. This computer can communicate directly with IBM PC, XT, and AT compatibles.

The MCGI-I is already in use in a 360-degree full-field-of-view flight simulator, where it can generate a controllable target or a lead aircraft flying in formation. In-use testing has shown that this computer is easy to operate, runs reliably, and provides clear images. Pertinent specialists have judged that this computer has a favorable performance-to-price ratio, that it is powerful, that its dynamic image transforms are smooth, and that it is suitable for use in generating and displaying controllable images of moving targets.

First Domestic Minisupercomputer

90CF0178D Beijing KEJI RIBAO [SCIENCE AND TECHNOLOGY DAILY] in Chinese 16 Nov 89 p 1

[Article by Zheng Dong [6774 2639]: "Successful Development of Unique New Minisupercomputer"]

[Text] Just as the appropriate departments were preparing to include development of a minisupercomputer within the Eighth 5-Year Plan, General Manager Jin Yanjing [6855 3601 7234] of the Beijing Communications Group announced that the ST-NS1000 minisupercomputer system had been successfully developed by that company, together with the Computer Department at Beijing University. The machine is only about the size of a 20" color television, but its calculation speed is 10 MIPS, and it has a high performance-to-price ratio.

For more than 2 years, the Communications Company has invested more than 2 million yuan in accumulated development capital toward this development effort, as S&T personnel overcame many technical difficulties. The ST-NS/1000 minisupercomputer has a unique bus design, it can directly process mathematical expressions, and it is suitable for such areas as petroleum and mineral exploration, aviation and space, scientific research, teaching, and technical engineering.

It is said that this computer will go into small-scale production next year and that nearly 20 units have placed orders for this machine.

More on First Minisupercomputer

90CF0178E Beijing ZHONGGUO DIANZI BAO in Chinese 1 Dec 89 p 1

[Article by Yang Zili [2799 5261 0500]: "Communications Group Develops China's First Minisupercomputer"]

[Summary] Additional details on China's first domestic minisupercomputer include the following: word length is 32 bits, the 16MB-64MB-capacity unified memory system uses a multiple cross-parallel-access technique, and the master clock frequency is 16.7 MHz. A Sun workstation is employed as the front-end processor, and the operating system is UNIX; the system is outfitted with an independently developed parallel FORTRAN language.

Multispectral Scanner With Programmable Spectral Bands

[Article by Wang Jianyu [3769 1696 1342] and Xue
Yongqi [5641 0737 4388] of the Shanghai Institute of
Technical Physics, CAS]

[Excerpts]

I. Introduction

This article discusses the characteristics of multispectral
remote sensing, and as a result of the analysis of terres-
trial object signals, suggests that different goals of remote
sensing should employ a different spectrum selection to
achieve the best spectral results. This will result in more
signal in the same number of spectral bands. In general,
for different terrestrial objects, different times and dif-
ferent locations have different optimal spectral bands.

A multispectral scanner with programmable spectral
bands is a kind of multispectral scanner that is based on
the principle of free selection of spectral bands. It is a
comparatively ideal piece of remote sensing equipment.
This article analyses at length the system principles and
parameters, and puts forth several implementation
plans.

[Passage omitted]

III. System implementation

There are many methods in the implementation of a
multispectral scanner system with programmable spec-
tral bands. This article discusses two such methods.

3.1 Analog iterative addition (or superposition) method

The block diagram of an analog iterative addition system
is shown in Figure 1. Several sensors receive n pre-
analysed spectral bands. The output signals from n
preamplifiers pass through a programmable switching
network. After passing through the analog adder, they

are organically combined into a small number (m) of
output bands. The switching logic is controlled by the
CPU. Changing the mode for combining spectral bands
before or during experiments requires only the transmis-
sion of appropriate program codes to the microprocessor
system. After amplification and necessary processing of
the combined m signals, they can be recorded by analog
tape recorders, or A/D converted and then recorded.
Although this method is based on a simple design plan,
the parallel treatment system can be comparatively enor-
mous. Especially when the number n is very large, this
method then becomes impractical.

3.2 Digital superposition method

The digital superposition method transforms parallel
analog signals that are output from n preamplifiers into
serial analog signals (or in the case of CCD devices, the
output signals are already in serial form). After passing
through the main amplifier, they are A/D converted into
serial digital signals. Then, digital circuits are used to
separate and to combine the data from the n spectral
bands. In this method, the entire system requires only
one channel, whose block diagram is shown in Figure 2.
The n parallel analog signals obtained from the pream-
plifiers first go through the parallel-serial transformation
circuit, so that the signals become serial analog signals.
Then they are amplified by the main amplifier circuit,
which consists of programmable amplifiers. The gain
from the programmable amplifiers is determined auto-
matically by the CPU in accordance with the magnitude
of the input signals. The amplified signals are trans-
formed into serial digital signals by A/D converter cir-
cuits. After the necessary processing of spectral-response
calibration and direct-current weight restoration, the
numerical data then enter programmable-combination
circuits to produce the combined spectral bands.
Because data rates are higher from n serially connected
channels, the time needed to process each piece of data is
minimal. Therefore, this part is processed completely by
hardware; the block diagram for the circuit is shown in
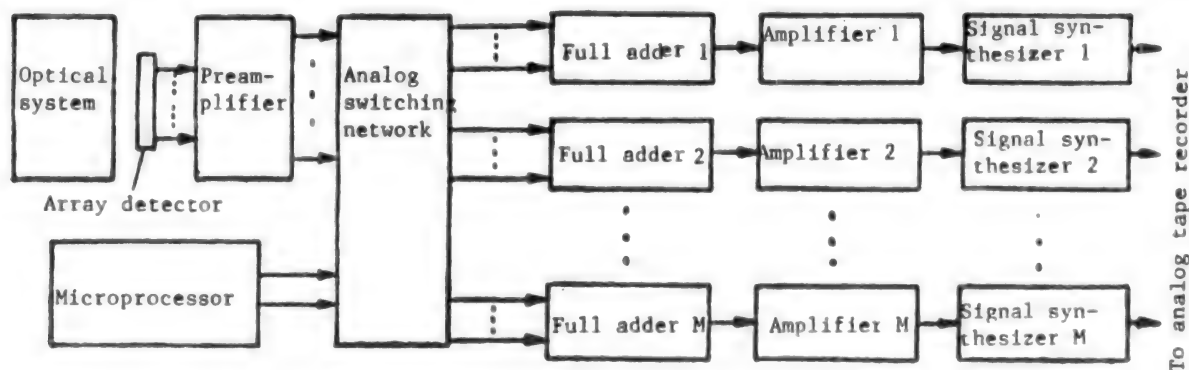Figure 3. The circuits, which have programmable

Figure 1. Block Diagram of Analog Superposition System

sequence control, produce organically combined spectral
bands. Also, signals that have been superposed are then
normalized; this guarantees that the final outputs of the
data of all the spectral bands have the same number of
digits. The whole system operates under the control of
the microprocessor; spectral-band programming and
data processing are both in real-time.

According to the digital superposition method, based on
the use of the DGS multi-spectral scanner, a prototype
has been developed in principle. The major indicators of
the prototype are as follows.

Operating bands: the 16 basic preassigned spectral bands
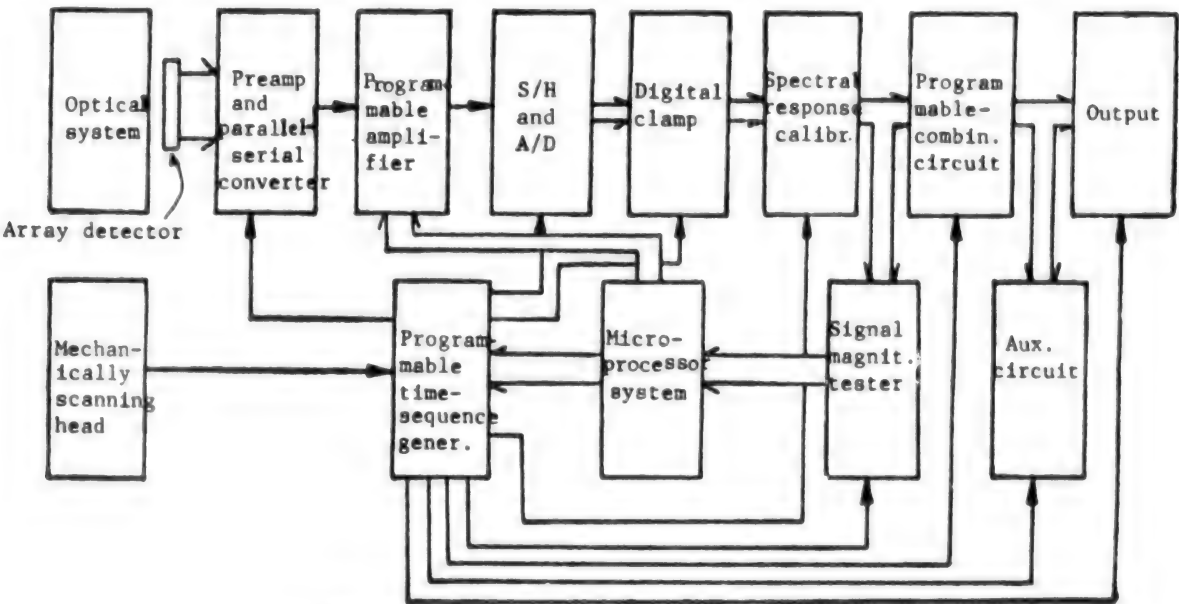in the visible and near infra-red range were combined

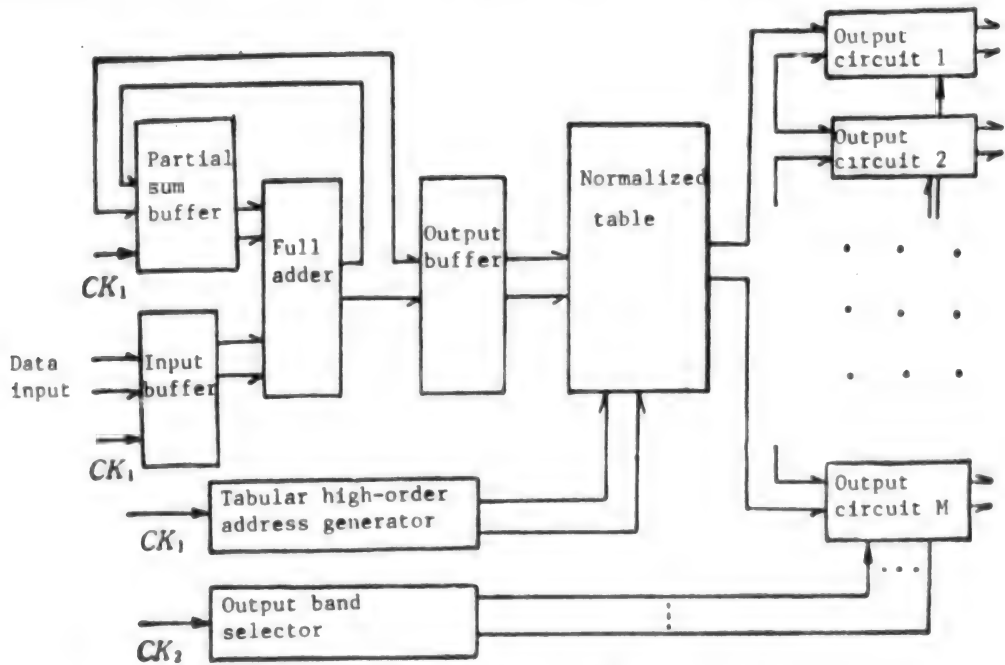Figure 2. Block Diagram of Digital Superposition System

Figure 3. Programmable Circuit of Band Combination

into two to eight parallel output bands. Total field of view: 90 degrees; instantaneous field of view: 3mrad; scan rate: 10-30 1/s; NE$\Delta\rho$: about 0.5 percent.

The direction of development of remote-sensing equipment lies in the improvement of the rate of spectral discrimination when using such scanners to explore the spectral bands of minute structures of terrestrial objects. Using programmable spectral bands prevents or at least minimizes the loss of interesting spectral signals from terrestrial objects. Also, the method can minimize the data rate of the system output. This method can conveniently produce some specified spectral-band combinations, such as TM, and MSS. Furthermore, this method can be used in real-time preliminary treatments of imagery spectrogram data. This can reduce the data rate of the imaging spectrogram output. Therefore, this research topic is of significant interest to the development of remote-sensing equipment.

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Using Li-Like Al Ions in Laser Plasmas to Achieve Soft X-Ray Amplification

[Article by Lu Peixiang [7120 1014 6116], Zhang Zhengquan [1728 2973 3123], Fan Pinzhong [540 0756 1813] and Xu Zhizhan [1776 5267 1455], all of the Shanghai Institute of Optics and Fine Mechanics [SIOFM], Chinese Academy of Sciences: "Using Li-Like Al Ions in Laser Plasmas to Achieve Soft X-Ray Amplification"]

[Text] Key Words: Laser Plasma, Soft X-Ray Spontaneous Radiation Amplification.

Soft X-ray amplification is an interesting research area. Jaegle et al. have already done some work to achieve soft X-ray amplification using Li-like ions.[1] This paper is a report of the results recently obtained in our laboratory.

I. Experimental

This experiment was carried out with an intense six-beam neodymium laser. The output energy of each beam was approximately 10 J and the pulse width was about 250 ps. Two laser beams 200 ps apart travel along the same optical axis through a cylindrical lens (R = 200 mm) and a F/1.5 non-spherical lens (f = 90 mm) which focus them onto a flat aluminum target. The focal line was 8 mm long and 200 μm wide. The mean light intensity was 2×10^{12} W/cm^2. In a previous experiment[2], we noticed the presence of a large-scale plasma jet structure between the hot plasma and cold target. In order to avoid this boundary effect to ensure the homogeneity of the entire plasma line, the width of the target (i.e., the length of the plasma) was chosen to be smaller than the length of the focal line. In this experiment, it was 6.3 mm.
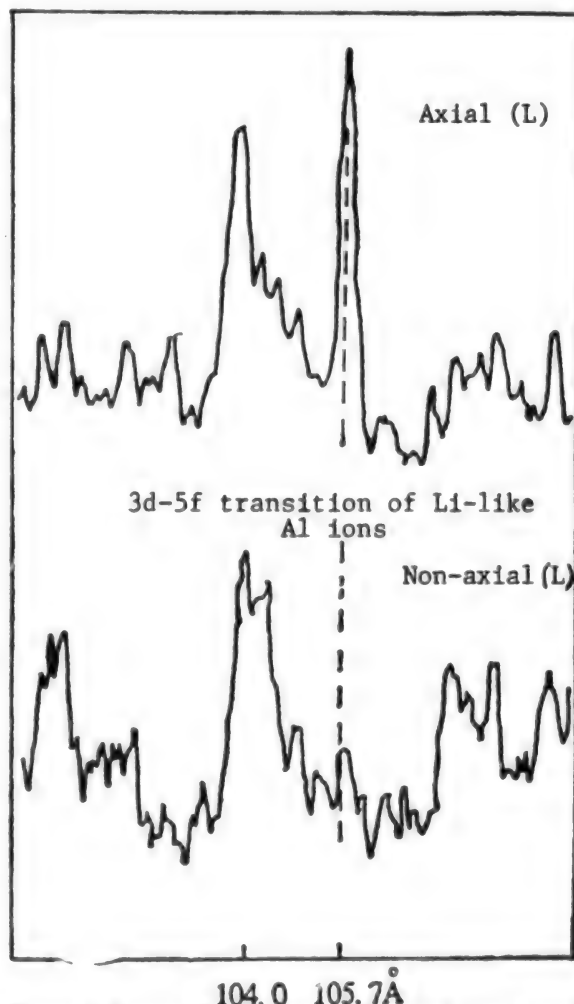

Figure 1. Linear Plasma Spectra Observed Along Axial and Non-Axial Direction; aluminum target: linear plasma 6.3 mm long, 200 μm wide

The emission spectrum was observed using a 1-m stigmatic grazing-incidence-grating spectrograph[3] (grating spacing: 1/2400 mm, wavelength accuracy: 0.05 zero over A, one-dimensional resolution: 50 μm) developed by our group. The spectral range observed was 10-120 zero over A. The spectrum was recorded using a soft X-ray film manufactured in Shanghai. The darkness scan curve of the spectrum was obtained using a Japanese-made MP-3 microphotometer.

The direction of the focal line was varied by rotating the cylindrical lens in order to observe the axial and non-axial (approximately 45° angle) emission spectra of the aluminum target.

Figure 1 shows the axial and non-axial darkness scan curves of the linear plasma. At 105.7 zero over A the intensity changes significantly, which corresponds to a strong spontaneous radiation amplification effect.

II. Results and Discussion

1. Figure 1 clearly shows that the 105.7 zero over A line was very intense when the linear plasma was observed along its axis. However, this line disappeared and became the background of the spectrum in non-axial observation. Experimentally obtained emission spectra of aluminum plasmas[4] show that there are no other spectral lines near 105.7 zero over A; there is only the 3d-5f transition of Li-like aluminum ions.[5] This indicates that the 3d-5f Li-like aluminum transition in the soft X-ray band, i.e., at 105.7 zero over A, undergoes spontaneous radiation amplification.

2. Using the following approximate formula for plasma temperature[6]

$$\frac{T}{1\,keV} = 0.6 \left[\frac{1}{f} \left(\frac{I_{abs}}{10^{14}W/cm^2} \right) \cdot \left(\frac{\lambda_L}{1\,\mu m} \right)^2 \right]^{2/3}, \quad (1)$$

we roughly estimated that the plasma temperature was approximately 60 eV. We assume that the temperature is 1 keV when the absorbed light intensity $I_{abs} = 10^{14}$ W/cm^2 and $I_{abs} = 0.7$ I. This relatively low temperature is just right for helium-like aluminum ions to become Li-like aluminum ions through three-particle recombination in order to create population inversion.

From the spectrum taken along the axis, we found that the one-dimensional spatial distribution of the 105.7 zero over A spectral line is shorter than other spectral lines. Moreover, its intensity peaks approximately 400 μm from the target surface. This may indicate that the intensity peak is located in the medium-density zone because plasma density decreases with increasing distance from the target.[7] This also indicates that the optimal condition for the rapidly adiabatically cooled plasma to produce a laser line at 105.7 zero over A, i.e., the optimal recombination condition, is behind the presence of the driving laser pulse.

3. The simple equation to calculate the gain factor is[8]:

$$I = Se^{GL} \quad (2)$$

In approximation, we get I/S = 3.5 from the curve. Hence, the gain factor was roughly estimated to be 2/cm. Here, the source functions was assumed to be the 105.7 zero over A line intensity when observed non-axially. I is the intensity of the line when observed axially.

This is an important study. In order to further verify this effect, much work must be done. For instance, one needs to obtain a gain curve by varying the length of the plasma in order to demonstrate that the intensity of the 105.7 zero over A (3d - 5f) Li-like line increases non-linearly with the length of the plasma.

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High-Pulse-Current Measurement Method for Raman Free Electron Laser

[Article by Chen Jizhong [7115 1015 1813], Lu Ziatong [7120 6528 6639], Zhang Lifen [1728 4539 5358], Wang Zhijiang [3769 0037 3068] and Wang Mingchang [3769 2494 1603], all of the Shanghai Institute of Optics and Fine Mechanics [SIOFM], Chinese Academy of Sciences: "High-Pulse-Current Measurement Method for Raman Free Electron Laser"]

[Text] Key Words: Raman free electron laser, high-pulse-current measurement method, Rogowski coil.

I. Introduction

The free electron laser (FEL) has shown bright prospects in tunable, super-high-power applications due to its ideal optical medium properties with free unbound electrons in vacuum.[1,2] After its physical mechanism was confirmed, the focus of research has switched from theory to experiment, and from experiment to perfecting existing lasers in order to improve their electron efficiency. In the overall experiment involving a Raman FEL, the synchronous and accurate measurement of an electron beam passing through the interaction zone becomes an important topic. Since the first Raman FEL in China was built at the Institute in 1986,[3] we have been constantly working on improving its electron efficiency. In order to measure the electron beam, we have used a very-low-resistance shunt method and the Faraday-cup method. In a recent experiment involving the use of a 1.2-m long interaction-zone Raman FEL, we successfully used the automatic-integration [i.e., self-integrating] Rogowski coil method[4]—originally developed in accelerator technology to measure high pulse currents—in our experimental apparatus to effectively solve the problem of synchronous measurement of an electron beam in a Raman FEL.

II. Principle, Design, Fabrication and Experimental Calibration of Rogowski Coil

1. A typical Rogowski coil is shown on the left of Figure 1. Its equivalent circuit and definition of parameters are shown in Figure 2a. From an analysis of the circuit equation:

$$\frac{1}{R}\frac{d\Phi}{dt} = \frac{L}{R}\frac{dI_c}{dt} + I_c$$

we know that the coil may operate in two states. When

$$\frac{L}{R}\frac{dI_c}{dt} \ll I , \quad I_c \cong \frac{1}{R}\frac{d\Phi}{dt} .$$

In this case, the coil is a "differential Rogowski coil." On the contrary, if

$$\frac{L}{R} \cdot \frac{dI_c}{dt} \gg I , \quad I_c \cong \Phi/L .$$

In this case, the coil current is only proportional to magnetic flux. This is the "automatic-integration-type Rogowski coil" used. If the decay constant of the coil is $\tau = L/R$, and let T be the transmission time, t_0 be the width of the original current pulse I, then the automatic-integration coil ought to meet the following conditions:

$$\tau \gg t_0, \quad T \ll \tau$$

A comparison of these two coils shows that the automatic-integration coil has the following advantages. (a) Since the magnetic conductive medium of the coil is nylon, whose magnetic permeability is close to that of air, non-linearity of signal does not therefore exist. Furthermore, the measured signal is independent of the fundamental frequency of the pulse current. (b) The excited signal has a fast response time. The automatic-integration coil is only limited by the coil itself and the external transmission time, while the response time of the differential coil is not less than L/R. (c) The measured voltage signal is not too large to go over scale. (d) The signal will suffer little distortion and loss.

Figure 1. Classical Rogowski Coil (left) and Newly Designed Small Rogowski Coil (right)

Figure 2a. Equivalent Circuit Diagram of Rogowski Coil; $R = R_{ps} + R_{CVR}$, i.e., the line resistance is equal to the sum of skin resistance and measured resistance; φ is the total magnetic flux of the coil, $\varphi = d\varphi/dt$; I_c is the induction current excited by the original current pulse I in the coil; L is the self-inductance of the coil; U_{out} is the output voltage signal.

2. Design and Fabrication

The skeleton of the automatic integration coil was designed based on the aperture of the guiding field coil and that of the drift tube (as shown in Figure 2b) according to the following equations:

$$L = N^2 \mu_0 A / 2\pi r,$$

$$T = (N/C) \cdot [\varepsilon_r(p^2 + l^2)]^{1/2},$$

$$\tau = L/(R_{CVR} + R_{\rho t}),$$

$$R_{\rho t} = \left(\frac{2r}{p}\right)(1/d) \cdot [\pi f \rho \mu_0(p^2 + l^2)]^{1/2},$$

where A is the cross-sectional area of the coil, N is the number of turns, p is the mean distance of the winding, l is the circumference of a single winding, d is the diameter of the wire, ρ is the resistivity of the wire, μ_0 is the 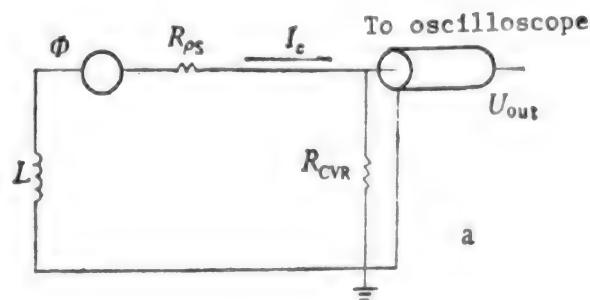magnetic permeability in vacuum and E_r is the relative dielectric constant. If $N = 25$, $A = 325$ mm^2, $r = 30.5$ mm, $E_r = 3.4$, d = 1 mm, $\rho = 1.6 \times 10^{-8}$ (Ω/m), $f = 16.7$ MHz, $R_{CVR} = 1\Omega$, we get $\tau = 2.51 \times 10^{-5}$ s and $T = 1.17 \times 10^{-8}$ s. Because $t_o = 60$ ns, the automatic integration condition for the coil is satisfied.
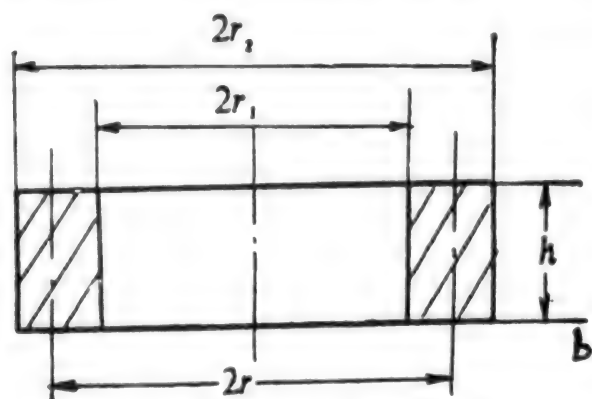

Figure 2b. Cross-section of the Coil

The automatic integration coil has the following relation: $U_{out} = R_{CVR}I_c = R_{CVR}\varphi/L$. Hence the sensitivity of the coil is defined as $k = I/U_{out} = N/R_{CVR}$. The theoretical design value of this coil is $k = 25$.

We used aluminum alloy as the primary material and designed the body and vacuum seal of the coil based on the structure shown above. In addition, a small Rogowski coil was constructed by taking eddy current effects and an electrostatic shielding structure into account, as shown in Figure 1 (right).

3. Experimental Standardization

There are many factors in the actual fabrication process contributing to errors in the coil. Therefore, it is necessary to measure the coil in order to determine its sensitivity. For this purpose, we developed a device to make such measurements. An experimental transformer was used to charge a piece of 75-ohm cable approximately 20 m in length. A high-voltage electrostatic voltmeter could accurately measure the charging voltage V. When V exceeds the threshold of the air switch, the switch breaks down and the cable discharges through the Rogowski coil. The amplitude of the discharge current I is equal to the charging voltage V at the breakdown of the air switch divided the characteristic impedance of the cable z_o.[5] The amplitude of the voltage signal from the coil U_{our} can be measured from the oscilloscope photograph. Thus, the standardization equation for the sensitivity of the coil is

$$k = V/(75.U_{out}).$$

We observed the discharge waveforms under different shielding and discharge conditions and found it to be a decaying series of pulses in the form of damped waves. The first peak is U_{out}. Our results showed that the mean measured sensitivity of the coil is $k = 36.1$. This is 30 percent off from the theoretical value and is within our expectation. This is because leakage of magnetic flux was not considered in the theoretical calculation. However, the actual coil was loosely wound so that the voltage signal to be measured U_{out} would not be too small. Consequently, the coil could not hold all the magnetic flux generated by the original current pulse. We will use the measured coil sensitivity to calculate the electron efficiency of the FEL.

III. Laser Experiment

In our recent 1.2-m interaction-zone Raman FEL experiment, the small Rogowski coil was used in the manner shown in Figure 3. After laser power came out of the conical funnel, some of it entered the carbon cone calorimeter equipped with a cutoff waveguide for measuring its energy. The energy of the laser can be thus calculated after conversion. The electron beam current corresponding to this laser energy was simultaneously measured with the Rogowski coil. Figure 4 [photograph not reproduced] shows a typical waveform of the electron beam.

The laser experiment showed that the electron efficiency of the 1.2-m interaction-zone Raman free electron laser has reached 3.7 percent. The Ka band (approximately 7 mm) laser pulse power output has reached 12 MW. The pulse width is greater than 30 ns. These results are close to the values attained with similar devices in other countries.[6]

The experiment also shows that the Rogowski coil method has the following advantages. The coil is small, thus effectively weakening the electromotive force generated by the guiding magnetic field. The coil acts as a transition interface at the drift tube to allow synchronous measurement of current and laser experiment. This

**Figure 3. Experimental Setup for the Raman
Free Electron Laser**

Key:
1. Diode-type high-current electron gun
2. Guiding magnetic field envelop
3. Newly developed 1.2-m interaction-zone
   variable-magnetic-field oscillator
4. Drift tube
5. Automatic-integration Rogowski coil
6. Energy meter
7. Crystal wave detector
8. Microwave-absorbing screen
9. Millimeter-wave measurement room
10. Electron parameter measurement room
11. Conical output window

avoids repeated exposure of the system to the atmo/sphere, which improves the accuracy of measurement and greatly reduces the experimental cycle. It has practical value to the investigation of new mechanisms in the Raman free electron laser and improvement of its electron efficiency.

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Photoluminescence Studies of GaAs/AlAs Short-Period Superlattices Under Hydrostatic Pressure

[English abstract of article by Li Guohua [2621 0948 5478], Jiang Desheng, Han Hexiang, et al., of the National Laboratory of Semiconductor Superlattices and Related Microstructures, Institute of Semiconductors, Chinese Academy of Sciences; and Klaus Ploog of the Max-Planck Institute for Solid-State Research, Stuttgart, West Germany]

[Text] The photoluminescence of $(GaAs)_m/(AlAs)_n$ short-period superlattices (SLs) is studied under hydrostatic pressure in the range of 0-50 kbar. The dependence of the difference between conduction-band Γ-like and X-like levels on the SL period length is obtained, independent of which level is higher. The Γ-X crossover has been observed for the first time at atmospheric pressure and at room temperature in a $(GaAs)_{11}/(AlAs)_{11}$ SL. The relative probability for X-like and Γ-like transitions at the Γ-X overcrossing may be derived from the pressure dependence of the corresponding luminescence intensities. It is found that the ratio of the two transition probabilities increased gradually from 1.4×10^{-4} for $(GaAs)_{17}/(AlAs)_{17}$ to 4.6×10^{-3} for $(GaAs)_6/(AlAs)_6$. This shows that the mixing between Γ-like and X-like states is quite small. The experimental results are discussed briefly.

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Energy Gap, Residual Electronic Specific Heat of High T_c Oxide Superconductors

[English abstract of article by Leng Manhua [0397 3341 5478], Shen Jiang [3947 3068], and Zhang Liyuan [4545 4539 3293], of the Department of Physics, Beijing University]

[Text] Making use of the free carrier-negative U center interacting mechanism to describe high T_c oxide superconductors, the authors have obtained the energy gap and estimated the residual linear electronic specific heat at low temperatures in the superconducting state of the La-Sr-Cu-O and Y-Ba-Cu-O systems. The numerical results of the energy gap for the above-mentioned two systems are $2\Delta(0)/(K_b T_c = 4.00$ and 4.22, respectively, and the coefficients of residual electronic specific heat are $C_1 = 2.25$ and 3.04 mJ/mol K^2, respectively. These numerical results are in approximate agreement with the experimental data. The authors have also come to the conclusion that it is the mixing interaction between the free carrier and the negative U center that enhances T_c on the one hand, and causes the instability of copper pairs and localized pairs on the other. In addition, it is this instability that leads to the intrinsic residual electronic specific heat, even in the superconducting state, at low temperatures.

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Large Step Change of Specific Heat in $YBa_2Cu_3O_{7-\delta}$

[English abstract of article by Li Jingwei [2621 7234 4850], Ran Qize [0373 0796 3419] et al., of the Institute of Physics, Chinese Academy of Sciences, Beijing]

[Text] The specific heat of the ceramic superconductor $YBa_2Cu_3O_{7-\delta}$ was measured in the temperature range of from 80 to 120 K using successive calorimetry. The results show that there is a large step change of specific heat $\Delta C_p = 7.1$ J/mol.K at the superconducting transition temperature $T_c = 92.4$ K. The ratio of $\Delta C_p/\gamma T_c$ is 2.05, which is much larger than the 1.43 value derived from the BCS weak-coupling theory. This suggests that the high-T_c superconductor $YBa_2Cu_3O_{7-\delta}$ is strong-coupling. By means of Debye's formula and lattice specific heat, the authors obtain mean value of $\theta_D = 424.7$ K.

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Effect of Sintering Times on Specific Heat of $YBa_2Cu_3O_{7-y}$ Samples

[English abstract of article by Ran Qize [0373 0796 3419], et al., of the Institute of Physics, Chinese Academy of Sciences, Beijing; Jin Rongying [6855 2837 5391], et al., of the Physics Department, Shanghai University of Science and Technology]

[Text] The specific heat around T_c has been measured on four $YBa_2Cu_3O_{7-y}$ samples with the same prescription but different sintering times, revealing that the discontinuity of ΔC at T_c becomes larger and the transition width grows narrower with the sintering time, although not noticeably so. The results also show that increasing the sintering time is not the ideal technique for improving the quality of the superconductor, even though it can increase the superconducting fraction.

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Phase Structure, Superconductivity in $(Bi,P)_2Ca_2Sr_2Cu_3O_y$ System

[English abstract of article by Xia Jiansheng [1115 0256 3932], et al., of the Department of Physics, University of Science and Technology of China, Hefei; Chen Jian [7115 0256], et al., of the Department of Applied Chemistry, University of Science and Technology of China, Hefei]

[Text] The conditions of preparation, the phase structure, $R(T)$, ac $\chi(T)$, $R(H)$, and $J_c(T)$ are systematically investigated for the $Bi_{2-x}Pb_xCa_2Sr_2Cu_3O_y$ system. Through a series of experimental observations, the laws of phase structure and the features of superconductivity are obtained, and the three superconducting phases, two critical magnetic fields and two critical currents in one sample are observed and discussed. Plenty of experimental data has been accumulated for researching high T_c superconductivity and for further understanding oxide superconductors.

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Superconductivity on $GdBa_2Cu_{3-x}Co_xO_y$, $NdBa_2Cu_{3-x}Co_xO_y$

[English abstract of article by Wang Shunxi [3769 7311 0823], He Zhenhui [0149 2182 1863] et al., of the University of Science and Technology of China, Hefei]

[Text] The single phase substituted superconducting oxide series of $GdBa_2Cu_{3-x}Co_xO_y$, $NdBa_2Cu_{3-x}Co_xO_y$ has been prepared by solid state reaction, and the lattice parameters and resistance dependence on temperature have been measured. It has been found that, with the increase of the amount of x substituted, (1) both series of samples show metal-semiconductor transition; (2) $NdBa_2Cu_{3-x}Co_xO_y$ demonstrates a structural transition from orthorhombic to tetragonal, with the superconductivity vanishing before this transition; and (3) the T_c of $GdBa_2Cu_{3-x}Co_xO_y$ decreases linearly with x. By selecting the appropriate x_{cr} and making a comparison with the AG curve, the deviation from AG theory in the high impurity content region is found.

Comparing $YBa_2Cu_{3-x}Co_xO_{7-y}$, $Ba_2Cu_{3-x}Fe_xO_{7-y}$, $YBa_2Cu_{3-x}Ni_xO_{7-y}$ and $GdBaCu_{3-x}Fe_xO_{7-y}$, the authors suggest that some magnetic interaction may exist between rare-earth elements and 3d-metals with large intrinsic magnetic moments. Other possible depairing mechanisms are also discussed.

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Magnetic Properties of TlBaCaCuO Superconductor in Low Applied Magnetic Fields

[English abstract of article by Ding Shiying [0002 0013 5391], Yan Jialie [7346 1367 3525] et al., of the Department of Physics, Nanjing University]

[Text] The fact that the magnetization curves of the TlBaCacuO superconductor have been found to have hysteresis loops shows that TlBaCaCuO is a type II superconductor. Two sections of straight lines in the virgin magnetization curve have been found and are thought to have resulted from flux shielding of the bulk sample and flux expelling of the granules, respectively. The departure from the straight line in the virgin magnetization curve happens below 10 Gausses of field strength. This means that weak flux pinning regions exist. This is a characteristic feature of the granular oxide superconductor. The determined low critical field H_{c1} is 270 G at 78 K.

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Measurements of Quality Factor of Microwave Cavity Containing YBaCuO Superconductor

40090012G Beijing DIWEN WULI XUEBAO [CHINESE JOURNAL OF LOW-TEMPERATURE PHYSICS] in Chinese Vol 12 No 1, Jan 90 pp 67-71

[English abstract of article by Gao Ruizhang [7559 3843 4545] and Qian Min [6929 3787] of the Information Physics Department, Nanjing University]

[Text] The quality factor Q_L of a rectangular cavity at a 3 cm band loaded with a YBaCuO bulk superconductor has been measured for both the normal and the superconducting states of the sample. An abrupt change in Q_L at the transition temperature is observed.

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Effect of Water on Superconductivity of $YBa_2Cu_3O_7$

40090012H Beijing DIWEN WULI XUEBAO [CHINESE JOURNAL OF LOW-TEMPERATURE PHYSICS] in Chinese Vol 12 No 1, Jan 90 pp 72-77

[English abstract of article by Zhang Yitong [1728 6318 4227], Ji Jiaben [1518 1367 2609] et al., of the Department of Physics, Nanjing University]

[Text] When applying high-T_c superconductors, superconductivity stability is the first problem to be resolved, especially when the the superconductor application is in moisture or water. Several papers have discussed this subject, but the authors have not located any results discussing the relationship of superconductivity to water quantity. In this paper, the authors introduce a method which measures the quantity of water in a $YBa_2Cu_3O_{7-\delta}$ sample by means of thermal energy neutron transmission.

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Update on Beijing Electron-Positron Collider

[Article by Yan Taixuan [0917 1132 3763] of the Insti-
tute of High-Energy Physics, Chinese Academy of Sci-
ences: "Beijing Electron-Positron Collider"]

[Text] The development of high-energy accelerators began
in 1950. The approach has been to bombard a stationary
target with high-energy charged particles. After converting
to a center-of-mass system, the effective energy is very low.
For instance, a 10 GeV proton only has an effective energy
of 2.8 GeV. If two 10 GeV protons moving in opposite
directions collide with each other, then the effective energy
is close to 20 GeV. This is equivalent to the effective energy
of using a 200 GeV particle to hit a stationary target. As far
as the electron is concerned, because of its small mass, this
effect is more significant. For instance, the collision of two
500 MeV electrons moving in opposite directions is equiv-
alent to hitting a stationary target with a 1000 GeV electron.
Therefore, colliders have attracted a great deal of interest
since 1960. After the first electron-positron collider
ADONE was built in Italy, colliders have been constructed
in the U.S., U.S.S.R., France, the FRG, and Japan. By 1980,
the collider had become the mainstream in the development
of accelerators.

In a glance, a collider is comparable in technology to a
conventional accelerator. However, it is quite different
after careful consideration. A conventional synchrotron
has a few seconds to a few minutes to accelerate parti-
cles. However, in a collider, particles must be stored for
several hours. Therefore, the requirements imposed on
the magnets and their installation are stringent. Simi-
larly, the vacuum requirement is also much higher;
otherwise, particles will collide with residual gas mole-
cules and will be lost. Just because of this long storage
time, problems that do not normally occur in other
accelerators, such as cluster instability caused by mutual
interaction between particles, are taking place inside a
collider. Theoretically, we have developed multiple par-
ticle theory from single particle theory. This indicates
that there are more problems to be considered in the
design of a collider than in that of a synchrotron.

The characteristics of synchrotron radiation must be taken
into consideration in an electron collider. As is well known,
photons are emitted while a high-energy electron is in
circular motion; this is known as synchrotron radiation. The
energy of synchrotron radiation is proportional to E^4/ρ
(where E is the electron energy and ρ is the radius of
curvature). It is easy to see that synchrotron radiation
increases rapidly with electron energy. Consequently, it
presents a higher demand on the accelerating voltage, cre-
ating more difficulties for the high-frequency system. Fur-
thermore, the bombardment of synchrotron radiation will
cause a great deal of degassing on the surface of the vacuum
chamber, thus leading to deterioration of the vacuum.

These are problems associated with synchrotron radia-
tion. However, synchrotron radiation also has some
advantages. Since synchrotron radiation decays as the
electron beam cluster becomes unstable, the tolerance of
some parts is more relaxed compared to that of a proton
collider. As for the positron, there is no need to employ
the special "cooling" technique for anti-protons. Due to
this special feature, the electron collider is known as a
forgiving accelerator.

Of course, synchrotron radiation itself is also a very
useful light source. It provides a new research tool in
molecular physics, surface physics, chemistry, molecular
biology, and photolithography for very-large-scale inte-
grated [VLSI] circuits. It is of unusually great signifi-
cance.

China has made numerous attempts to develop high-
energy accelerators. However, we were limited to the
stationary-target approach. Particularly, because we
started late and do not have sufficient funding, we are
facing a very serious challenge. It is obviously impossible
for us to build a high-energy accelerator and put us
among other leaders in the world. Nevertheless, it does
not make much sense physically to build a lower-energy
accelerator. The Beijing electron positron collider
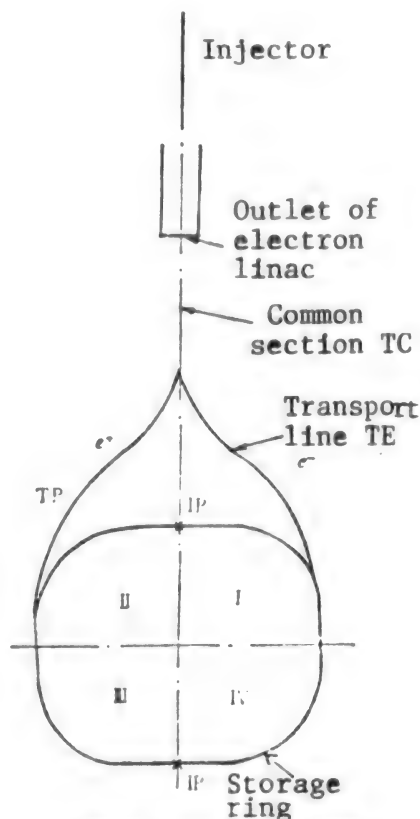(BEPC) just happened to solve this dilemma.

Figure 1. The Overall Layout

First, the energy of the BEPC is not too high and the investment is not prohibitively high for the Chinese economy to bear. Although the technical requirements are high, they are achievable through hard work. Next, one important parameter of a collider is brightness [or luminance], which is a function of energy. A collider reaches its maximum brightness at a specific energy. This allows us to choose an appropriate energy level over a certain range at which brightness is the obvious advantage. This allows us to do some work which is physically significant.

Based on this line of thinking, the energy of the storage ring was set at 2.2-2.8 GeV. The collider consists of an injector, a transport line and a storage ring. The injector is a standing-wave linear electron accelerator, approximately 200 meters long and 1.1-1.4 GeV in energy. After travelling in a common transport section, electrons and positrons output from the injector arrive at the storage ring via separate transport lines. The storage ring is a race-track type accelerator, approximately 240 meters in circumference. The overall layout is shown in Figure 1.

I. The Injector

The injector is a linear electron accelerator, consisting of a pre-injector, a positron source and the main accelerating section. Its operating frequency is 2856 MHz. The pre-injector consists of an electron gun, a fore beam buncher, a beam buncher with $\beta = 0.75$ and a 3.05-m-long section of accelerating tube with $\beta = 1$. The purpose of the pre-injector is to bunch the electrons within a certain phase width. Because the degree of energy dispersion is expressed by $\Delta E/E = 1/8(\Delta\varphi)^2$, this lowers the energy dispersion. The positron source is composed of a positron generating target, a pulsing magnetic jacket and its pulse power supply, two 3.05-m-long sections of accelerating tubes, two 20 MW klystron amplifiers and a uniform solenoid. The target bombardment energy was chosen at 150 MeV. The target is a 10-mm-thick tungsten target. Under the conditions that the incident electron beam radius is 1 mm, positron energy is in the range of 2-10 MeV, lateral positron momentum absolute value of P_t less than or equal to 0.68 MeV/c, and positron beam radius is 2.2 mm, the positron yield is $Y = 0.02$ e$^+$/e$^-$ GeV, based on the Monte Carlo method.

In order to raise the positron capture efficiency, a magnetic jacket focussing structure is located behind the positron target. Its function is to allow positrons with momentum greater than 0.68 MeV/c or beam radius larger than 2.2 mm to be accelerated through adiabatic compression by the magnetic field. A schematic diagram of the magnetic jacket is shown in Figure 2. It consists of a uniform solenoid wrapped around a porcelain tube. Inside the tube is a copper jacket, the same length as the uniform solenoid. The outer side of the jacket is cylindrical and the inside conical. The inside and outside are connected by a lateral notch. A hole is opened at the top of cone and it is aimed at the positron target. When a current pulse passes through the uniform solenoid, an inductive current is generated on the outer cylindrical surface of the copper jacket. This current flows through the notch into the inner conical surface and produces an adiabatic compressive magnetic field B(z) along the axis of the magnetic jacket:

$$B(z) = B_i \sqrt{1 + \alpha z} \quad (2)$$

where B_i is the magnetic field strength at the beginning end (Z=0) of the magnetic jacket and α is the adiabatic compression coefficient. If the inner aperture radius and lateral positron momentum at the beginning end are r_i and P_{ti}, and the magnetic field strength, inner aperture radius and lateral positron momentum at the end are B_f, r_f and P_{tf}, respectively, then

$$\frac{r_f}{r_i} = \frac{P_{ti}}{P_{tf}} = \left(\frac{B_i}{B_f}\right)^{\frac{1}{2}}$$

Due to the magnetic jacket, the positron capture rate can be raised by 10-15 percent.

Figure 2. The Magnetic Jacket

The $\beta = 1$ main accelerator tube accelerates positrons to their final energy. The entire linear accelerator has 16 30-MW-peak-power klystrons. Each klystron has a modulator which provides a high-voltage pulse up to 250 kV. The high-frequency power of each klystron is transmitted into the accelerator tube through a waveguide. This is similar to the arrangement in other standing-wave linear electron accelerators; the only difference is that an energy doubler is used in this device.

Since there are two collision points in the storage ring, there are only two beam bunches, i.e., electron beam bunch and positron beam bunch, in the storage ring. The pulse width of each beam bunch is under 5 nanoseconds. On the other hand, the high-frequency pulse of the injector is 2-3 microseconds. Hence, if the high-frequency pulse can be compressed in time and power, a higher-power pulse can be obtained within a shorter pulse width. Electron energy is also increased. At the same time, the beam width requirement imposed by the storage ring is satisfied. This is the function of the energy doubler.

The principle of the energy doubler is shown schematically in Figure 3. Two high-Q cavities operating in the TE_{015} mode are used to store energy at the front end of

Figure 3. Principle of the Energy Doubler

the klystron pulse. A PIN electronically controlled phase shifter is used on the back end of the pulse to invert the phase of the output of the klystron. The energy released by the cavity and the energy from the klystron add up at the accelerator end to realize energy dou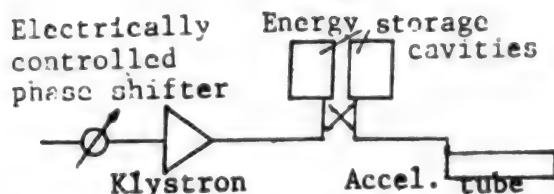bling. After the addition of the energy doubler, the output of the klystron can be compressed from 3 μs to 0.83 μs. The original design called for the use of 28 16-MW klystrons. This has been reduced to 16 to obtain the desired energy level.
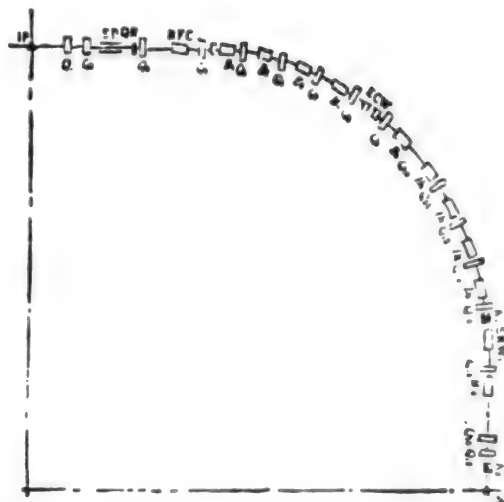
When electrons are being accelerated, all one has to do is to remove the positron target.

II. Transport Line

The functions of the transport line are (1) to deliver the beam from the linear accelerator to the incident point of the storage ring and (2) to complete matching of the optical characteristics of the injection beam. It consists of a trunk line (TC) and two branches (TP and TE). The two branches are symmetric and they are for e^+ and e^-, respectively. The entire transport line is composed of components such as deflecting bipolar magnets, focussing quadrupolar magnets, correction magnets, vacuum channels and beam detectors. Since there is a 3-m difference in height between the beam plane in the linear accelerator and that in the storage ring, both TP and TE have a vertical deflecting magnet to deflect the beam upward by 8°. This magnet and the cutting magnet at the injection point form a vertical deflecting joint to bring the beam to the storage-ring beam level. There are six pieces of quadrupolar magnets to match the beam for injection. In addition, there is a group of directional magnets which can be used to alter the horizontal injection angle. The length of TC is 30.6 m. Each branch is 88.9 m in length. There are 35 bipolar deflecting magnets (including iron-based beam cutters) and 42 quadrupolar lenses.

III. Storage Ring

The storage ring is the core of a collider. Positrons and electrons are accelerated and stored in the ring. Finally, they collide at a specified point. Figure 4 is a diagram showing the focussing structure of ¼ of a ring. Because synchrotron radiation may be provided for use, the placement of synchrotron torsional-pendulum magnets is also considered. Each basic structure unit is 6.6 m long, and consists of two quadrupolar focussing magnets, two bipolar deflecting magnets, two 1-m-long linear sections and two 0.3-m-long short sections. In order to meet special
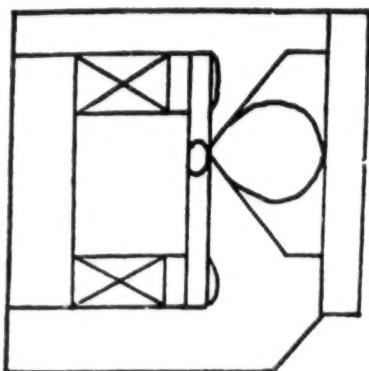

Figure 4. Focussing Structure of ¼ of Storage Ring

requirements in the injection and collision areas, there are two low-β inserts and two symmetric sections for injection. The total circumference is 240.4 m.

The purpose of the low-β insert is to enhance the brightness of collision Lumen. Brightness Lumenα(1 over β_{y^*} + 1 over β_{x^*}) and β* is the envelope function at the point of collision. Usually $\beta_{x^*} \gg \beta_{y^*}$, i.e., β_{y^*} should be as small as possible to maximize the brightness. Usually, β_{y^*} is the chosen to be comparable in length to that of the beam bunch. In the case of the BEPC, β_{y^*} = 0.1 m. The low-β insert is composed of four quadrupolar magnets, Q_1-Q_4, and four linear sections. It is 13.7 m in total length. Q_1 and Q_2 are inserting quadrupolar magnets, approximately 0.6 m in length. Q_3 and Q_4 are normal quadrupolar magnets, approximately 0.4 m in length. There is a 1-m-long linear section between Q_1 and Q_2 with a pair of horizontal and vertical calibrating bipolar magnets. There is a 4-m-long linear section between Q_2 and Q_3 with electrostatic separation plates and oblique quadrupolar magnets installed along the line. The 4.2-m straight line between Q_3 and Q_4 is used by the high-frequency accelerating cavity. The distance between Q_1 and the point of collision is 2.5 m. Thus, a 5-m-long linear section is available for physical experiments.

The symmetric section is formed by two normal quadrupolar magnets Q_{16} and Q_{17} and a 2.55-m-long straight line. The beam is injected from inside of this symmetric section into the ring through the iron-based cutting magnet. Three pulse-impact deflecting plates are installed in this area, forming a convex track system which deviates horizontally away from the axis of the storage ring in the injection area. When the injected beam exits the iron-based cutter, it is on the same plane as the ideal trajectory. It is injected into the ring at an angle of -1.5 milliradians. The center of the injected

Figure 5. Cross-Section of the Cutting Magnet

beam is off by 30 mm with respect to the center of the convex track. The beam bunch oscillates freely around the ideal trajectory in a coherent damping mode at an initial amplitude of 30 mm. After decaying for a period of time, the track is closed up, ready for the injection of the next beam bunch. Due to the shielding effect of the cutting magnet, the injected beam has already passed from the inside of the cutting magnet and has no effect on the next beam bunch to be injected. Figure 5 shows a cross-section of the cutting magnet. Normally, because a positron beam has a lower current, it is injected first. It takes approximately 30 minutes. Electrons are then injected and this only takes 1 minute. In order to prevent positrons and electrons from colliding with each other at the points of collision during injection and acceleration, a pair of electrostatic separators are placed on either sides of the collision point to separate the two beams vertically. When collision is desired, one simply removes the electrostatic separators.

The accelerator is also equipped with calibration magnets (bipolar) for track-closing calibration, chromaticity-calibration magnets (hexapolar), beam position and intensity probes, vacuum pumps, torsional-pendulum magnets to control beam-injection angle, and torsional-pendulum magnets for synchrotron radiation experiments.

Figure 6 shows the envelope curve square root of β and dispersion curve D. It is obvious that the dispersion function is zero in the low section and symmetric section. This is to facilitate beam collision and to avoid the coupling of longitudinal and transverse oscillation when the beam passes through the high-frequency cavity.

A very important factor determining the quality of the storage ring is the quality of the magnets. The entire system of magnets includes 40 bipolar magnets, 60 quadrupolar magnets, 4 low-field bipolar magnets, 8 insertion quadrupolar magnets, 4 horizontal calibration magnets, 34 vertical calibration bipolar magnets, 4 oblique quadrupolar magnets, 36 calibration hexapolar magnets, 4 brightness torsional-pendulum magnets, and 4 synchrotron-radiation torsional-pendulum magnets.
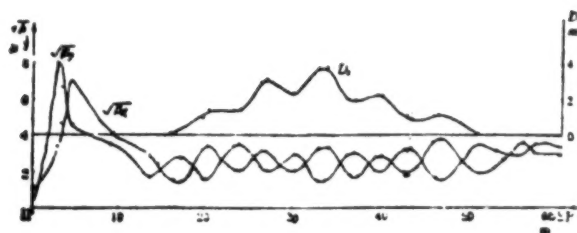

Figure 6. Envelope Function and Dispersion Function

The bipolar and quadrupolar magnets are most essential and critical. The requirements on their quality are also very stringent. In order to ensure quality, the advanced overlapping iron-core technique was used. The steel plates were matched based on their characteristics to meet the requirement that every magnet be homogeneous.

The bipolar magnets have a C-shaped structure for ease of installation and maintenance in a vacuum chamber. This also facilitates bringing out the synchrotron light. The air gap of the bipolar magnet is 70 mm and its effective length is 1.6 m. To facilitate machining, a straight iron-core scheme was chosen. However, because the turning radius of the beam is 10.345 m, it is necessary to take the 31-mm arc difference into account. Therefore, the favorable field width increases from 120 nm to 150 mm. The distribution of magnetic field should be better than 2×10^{-4} in the favorable field. The highest field strength is 9280 gauss.

The quadrupolar magnet consists of four individual units with symmetric hyperbolic surfaces. The radius of the inscribed circle is 55 mm and the effective length is 400 mm. The maximum field gradient is 1118 gauss/cm. It is required that the higher-order-to-quadrupolar ratio be kept at below 10^{-3}. Figure 7 shows its cross-section.
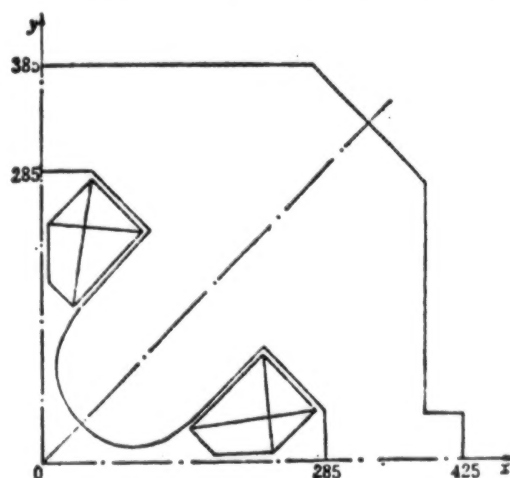

Figure 7. ¼ Cross-Section of the Quadrupolar Magnet

Both types of magnets are made of 0.5-mm-thick DW540G iron plate. The accuracy requirement for the plates is to have a mean deviation of plus or minus 0.025 mm. After stacking and welding these plate to complete the magnet, the pole surface error should be controlled to within 0.05 mm. The stacking coefficient should be over 97 percent. In order to ensure the quality of the magnets, both types of magnets have a flexible compensating pole structure to minimize any deleterious effect on the magnetic field due to processing.

The beam cross-section in the storage ring follows a Gaussian distribution. In order to ensure that the beam has a long-enough life, the dimensions of the vacuum chamber are calculated as follows:

BSC_x = plus or minus ($10 \, \sigma_{xmax}$ + 10mm)

BSC_y = plus or minus ($10 \, \sigma_{ymax}$ + 5mm)

where σ_{xmax} and σ_{ymax} are the mean square-root half width of the beam in the horizontal and vertical direction, respectively. Based on BEPC parameters, BSC_x = 120 mm and BSC_y = 70 mm. Hence, the vacuum chamber was designed accordingly.

It is necessary to minimize the losses due to Coulombic scattering and braking radiation from interaction between residual gas molecules and high-energy electrons in the storage ring. To this end, the background pressure in the tube must be better than 5×10^{-8} Pa. In the presence of a beam, the inner wall of the vacuum undergoes a great deal of degassing from photoelectrons generated by synchrotron radiation. Therefore, the vacuum is allowed to go down to 4×10^{-6} Pa.

The vacuum chamber is made of A16061-T4 aluminum alloy which has a high thermal conductivity and low electron-induced desorption coefficient. It employs a triple-chamber structure, as shown in Figure 8. The beam channel is in the middle. The distributive ion pump is on one side and the cooling water is on the other side.

Figure 8. Cross-Section of the Vacuum Chamber

The distributive ion pump has a stacked anode design, as shown in Figure 9. The anode is composed of eight pieces of stainless-steel plate with holes and the cathode is three pieces of titanium plate. Its operating principle is similar to that of a bipolar sputtering ion pump; however, in this case the magnetic fields between the magnets are utilized. In addition to the distributive ion pump, approximately 36 100-1/s ion pumps are used to maintain vacuum. In special devices such as the high-frequency accelerating chamber, static separator and impact deflecting plate, 400-1/s ion pumps are also used.
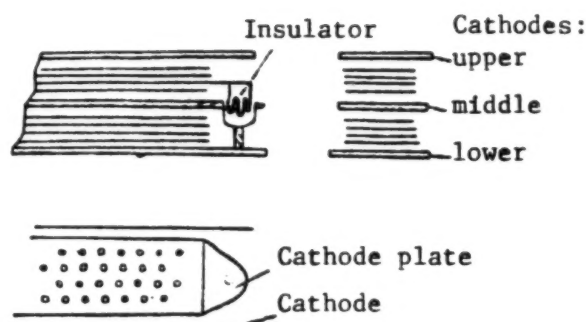

Figure 9. Distributive Ion Pump

Due to the presence of synchrotron radiation, electron energy will gradually decrease. Therefore, it is necessary to have a high-frequency accelerating cavity to provide high-frequency voltage to compensate for this loss. The magnitude of the voltage depends on the life of the beam. At 2.8 GeV with synchrotron radiation loss at 522 keV/cycle, if electron beam life is expected to be 50 hours and high frequency is set at 200 MHz, then the accelerating voltage is 1.35 MV.

The high-frequency accelerating cavity is a dual-inlet cavity operating in the TM_{010} mode. The cavity is made of copper and steel to ensure good electrical conductivity and mechanical strength. The cavity is completely sealed and its major parameters are shown in Table 1. There are two high-frequency cavities. Each one is excited by a 100-kW high-frequency generator. Each 100-kW high-frequency generator consists of four 25-kW high-frequency generators. Their outputs are combined to reach 100 kW. The high-frequency power is transmitted through a coaxial cable to a ceramic window and delivered into the high-frequency cavity via inductive coupling.

Table 1

Impedance ZT^2	Q	Max. Cavity Loss	Max. Beam Load
20 MΩ/m	40000	46 kW	36 kW

The entire accelerator is computer controlled. Obviously, it is a large-scale, real-time, multi-program, multi-tasking control system. This control system uses a VAX11/750 as its main computer. This computer has 4 MB internal memory, 912 MB disk capacity and various peripheral equipment. In addition, there are three control consoles and each is equipped with color monitors, touch screens, and program-controlled knobs. The CAMAC [computer-automated measurement and control] chassis has over 30 plug-in devices and timing systems capable of performing over 400 functions. Every subsystem has a local control station. This control system can automatically refresh over 10,000 controlled signal from 800 pieces of equipment of more than 30 types at a rate of several times per second and it can collect these signals in a large real-time database. The

database also stores dozens of attributes of each controlled signal to match with the control software and application software. It is capable of controlling the operation of over 1100 power supplies around the storage ring at an accuracy of one ten-thousandth, collecting and processing data from hundreds of beam monitors on the ring and along the transport line, and monitoring and controlling the 16 modulators and klystrons on the injector.

Preliminary design of the BEPC began in 1982 and construction officially began in 1984. The equipment was installed in 1988. The injector was first tested in November and the maximum energy of 1.23 GeV was reached in December. Then, the transport line was also successfully tested. Afterward, a beam was injected into the ring and signals were received for five circles. After exercising the first high-frequency cavity in early 1988, the voltage met the design specification. At the same time, the positron source was also tested. Following smooth injection of e^+ and e^- into the storage ring, the first collision took place on 16 Oct 88. It reached a brightness of $3 \times 10^{28}/cm^2s$. After repeated tuning, it was raised to $2 \times 10^{30}/cm^2s$ (at 1.6 GeV). Recently, the energy has been raised to 2.2 and 2.8 GeV and preliminary collision experiments have been successful.

After a year of testing and tuning, all components have been rigorously tested. Their quality has been proven. All major parameters have met world-class level for comparable accelerators built in the 1980's.

This paper was written based on internal reports of the Institute of High-Energy Physics of the Chinese Academy of Sciences. The author wishes to express his gratitude to all the people involved.

Photographs on bottom cover: upper right is the injector of the BEPC, upper left is a part of the storage ring, lower right is the transport line, and lower middle is the central control room.

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